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Feasibility Study for a Remote Terminal Central Computing Facility Serving School and College Institutions. Volume I, Functional Requirements.

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The economic and technical feasibility of providing a remote terminal central computing facility to serve a group of 25-75 secondary schools and colleges was investigated. The general functions of a central facility for an educational cluster were defined to include training in computer techniques, the solution of student development problems in mathematics and the sciences, and basic administrative tasks. An analysis of task requirements in terms of demand estimate s was followed by the selection of equipment and systems structure for four model regions differing in number of schools and average enrollment. The delineated systems were then validated by sampling actual requirements of a geographic area approximating one of the model regions and fitting derived demand requirements to system capacities. The Computer System Simulator program developed by IBM was also employed to evaluate the system's workload capacities and determine probable response times. Both simulation techniques indicated the system configurations would be entirely feasible and within given cost ranges. A recommendation was made for further study and pilot implementation. Details of cost estimates and simulation procedures are included in appendices. (SS)

ED027737

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IBM

Feasibility Study for a Remote Terminal Central Computing Facility Serving School and College Institutions

Volume I: Functional Requirements

EM007103

FOREWORD

This study was prepared over a four-month period by an IBM study team selected from throughout the company. The team was composed of IBM personnel from the following organizations: Instructional Systems Department, IBM Data Processing Division; GEM Regional Headquarters of the same division; IBM Systems Development Division; Instruction Systems Development Department, IBM Corporate Staff; and Schools Development Center, IBM Data Processing Division Headquarters. In addition, numerous consultants from within the various divisions and departments of the IBM Corporation served from time to time.

The findings of this study represent the best technical judgments of the members of the IBM study team, and do not represent any official statement of policy of the IBM Corporation. Furthermore, the discussions of data processing equipment and programming systems are in response to the specific objectives of the USOE Study Contract, and in no way should be considered product commitments or specific development plans of the IBM Corporation.

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Oakland, California City Schools

Palo Alto Unified School District

Sacramento County Regional Center

California State Department of Education

Sacramento Unified School District

Project OTIS (Oregon Total Information System)

Hotchkiss School Seminar

Fairfax Schools

Iowa Measurement Research Center

Texas State Department of Education

Chicago City Schools

Illinois Institute of Technology

Oakland Michigan County Schools

Toronto, Canada Schools

Nashville Metropolitan Board of Education

State University of New York

Central Atlantic Regional Laboratory (CAREL)

Dartmouth College

Phillips-Exeter Academy

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INTRODUCTION

On April 20, 1967, the U.S. Office of Education awarded the International Business Machines Corporation a contract to conduct a feasibility study for a remote terminal central computing system to serve secondary schools and colleges.

The contract was awarded to IBM on the basis of its proposal responding to a formal advertised request for proposal dated December 30, 1966, and a letter of solicitation from the Office of Education, received January 9, 1967. Work began on May 1, 1967 and was concluded on September 7, 1967.

The primary purpose of the study was to determine the economic and technical feasibility of providing modern data processing services to large numbers of students in order that such students may become familiar with modern data processing techniques. As a secondary purpose, the procurement specified that "routine" administrative functions normally accomplished by data processing equipment should be supported by the same system.

The statement of work further required that the Remote Terminal Centralized Computing System should be capable of providing the following services:

1. Problem Solving. Compute solutions to student problems in mathematics, science, and other academic subject areas.
2. Data Processing Training. Train students in the use of standard high-level programming languages, such as FORTRAN, COBOL, and PL/I.
3. Administrative Data Processing. Perform student scheduling functions, maintain school records, prepare reports, and so forth.

The statement of work also required that "computing support to the students will include complete diagnostics in source language and a job turn-around time of less than five minutes. For administrative data processing tasks, the system will provide only standard programs which are common to all users, and can tolerate longer turn-around times."

Additional factors that were to be considered during the study were presented at the bidder's conference on January 19, 1967 in Washington, D.C. A summary of these additional factors follows:

- The study will determine the economic parameters of supplying computer services to small- and medium-size educational institutions through remote terminals from a large central computing center. Cost acceptability is a major factor in establishing feasibility of a computing system designed for the school and college population.
- No computer-assisted instruction should be contemplated for this system unless it is concerned with the teaching of standard high-level programming language, and then only to the extent that it is economic to do so.
- The 50 educational institutions should be considered to be secondary schools, junior colleges, and four-year colleges, varying in size from 500 to 5000 students. These institutions would be located within a 100-mile radius. (Subsequent to the award of the contract, USOE required that no four-year higher educational institution should be included as users of the system.
- Equipment specifications need not relate to items concurrently available, and may include items to be first delivered within from 18 to 24 months.

The scope of work was specified in the request for proposal as follows:

1. Collect data on present educational usage.
2. Estimate input and output and computational requirements necessary to adequately furnish the services required.
3. Carry out two preliminary designs as described below:
   a. Keyboard-type student consoles operated on a time-shared basis.
   b. Moderately high-speed readers and printers operating on a multiprogrammed basis. This system is to provide for a high-priority program to run until such time as it must wait for peripheral equipment operations, at which time the next-highest priority program would run until it must wait, and so on. At such time as the peripheral operations are completed on a suspended program, it would run again.
   c. For both systems the following specifications were required:
      (1) Communications system parameters, including the buffer sizes
      (2) Fast memory speed and size
      (3) Auxiliary memory size, access, and transfer rates
      (4) Central processor parameters and utilization
      (5) Average turnaround times for various usages
      (6) Approximate cost of the facilities reflected in the preliminary designs
      (7) A recommended or appropriate billing system which would be compatible with such a facility

The configuration for the remote terminal computing system involves equipment installed at the computer center and equipment installed at schools, junior colleges, and administrative centers. Computer center equipment comprises a central processing unit with main storage and secondary storage facilities. Secondary storage consists of high-speed, random access disk devices; low/medium speed, random access cell devices; and low speed, sequential access tape devices. Input/output facilities consist of online printer, card read, card punch, and document reader units.

The computer center communicates with the remote sites through a communication control unit that uses leased or rented communication facilities.

Remote site equipment includes administrative terminals and instructional terminals.

Administrative terminals consist of a keyboard and attached typewriter printer, card reader, and card punch units. Instructional terminals are low-cost typewriter terminals.

Users of the administrative terminal include both teachers and administrators and students in data processing training programs. Teachers and administrators use the system to access certain files for a wide variety of administrative tasks. Data processing students use the capabilities of the terminal to enter punched card programs and to obtain printed program runs. The terminal is also used for an instructional terminal.

Users of the instructional terminal are teachers and pairs of students who use the terminal for 20-minute problem-solving sessions in science and mathematics. Through the use of a special problem-solving language, users operate the terminal in a conversational mode for a quick interchange of questions and answers.

Excess data processing training workloads and problem-solving workloads are handled by overnight batch processing. Overnight batch processing involves two methods. In the first method, student programs and problems are keypunched using the administrative terminal's card punch in an offline mode. Cards are then read and sent via the terminal to the computer center for processing overnight; results are transmitted from the computer to the terminal printer by the following morning. Cards may also be sent to the computer center via a carrier, who may also pick up printed results from the previous overnight processing cycle. The combination of processing options provides reasonable access to the computing center for both administrative users and students at a reasonable cost.

Administrative terminal users have direct access to central student, staff, curriculum, property, and fiscal information files for queries and a wide variety of reports as defined by the needs of the individual schools and administrative centers.

System configuration will vary with the composition of school regions. Enrollment figures, distance between the locations, and number of locations served have an impact on equipment characteristics and number of terminals required. These factors, in turn, affect system costs.

Three model regions (A, B, C) and a case study region defined by IBM, and a USOE region, were analyzed; equipment was selected on the basis of the individual needs of the regions. Costs were then projected, and the system configuration was simulated for all five regions. Simulation results on the percentage of equipment utilization for the five regions confirmed the technical feasibility of the system configurations.

Cost projections confirmed the economic feasibility objectives established early in the study.

The measure of "economic feasibility" was calculated as follows:

1. Estimate total system cost (excluding initial development expense).*
2. Deduct costs applicable to administrative use as follows:
    a. Business services: 50¢/elementary student, $1.50/secondary student
    b. Pupil administrative services: 60¢ for 37.5% of elementary students, $4.00 per secondary student
3. The remainder represents costs for instructional use. Such costs should not exceed one to two percent of the school district's total operating costs, based on a national average operating cost of $532 per student.

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*"Operating costs" are defined to include computing equipment and maintenance expense on a rental equivalent basis, communication facilities, and manpower and supplies to directly support the system. They exclude capital and overhead expenses for facilities in which to house the central computer, assigned general and administrative costs, startup costs, and initial development expense. They also exclude costs for instructional materials.

Table 1 correlates the five regions studied with equipment requirements, costs, and simulation results.

Table 1

SUMMARY

Region Statistics	A	B	C	USOE	Case Study
Total Enrollment K-12	160,000	320,000	480,000	400,000	404,642
Total Enrollment 9-14	42,000	84,000	126,000	104,000	93,383
Total Locations	27	54	81	54	61
Total Annual Problem Solving Sessions	273,060	546,120	819,180	674,400	-
Total Annual DP Problem Sessions	42,400	84,800	127,200	104,400	-
Total Problems	315,460	630,920	946,380	778,800	507,000
Total No. Instructional Terminals	58	116	174	156	147
Total No. Administrative Terminals	29	58	87	58	69
Total Region Operating Expense	$86,184,000	$172,368,000	$258,552,000	$214,928,000	$247,018,400
Total Annual System Costs	$791,900	$1,202,600	$1,677,000	$1,455,600	$1,246,069
Ratio System Cost to Operating Expense	0.86%	0.70%	0.65%	0.68%	0.50%
Administrative Costs Assigned	$307,000	$614,000	$921,000	$688,100	$704,811
Instructional Costs Assigned (9-14 students only)	$484,900	$588,600	$756,000	$767,500	$541,258
Ratio Instructional Cost to Operating Expense (9-14 students only)	2.2%	1.3%	1.1%	1.4%	1.0%

PART 1: CONDUCT OF STUDY

This part outlines the approach to the study in terms of the individual tasks performed, summarizes the results of each task, and presents the conclusions and recommendations.

TASK DEFINITION

To define a system that meets all instructional and administrative objectives and the overall system requirements, seven study task areas were established:

Task 1. Establish general system requirements.
Task 2. Identify and quantify the user population for the instructional task.
Task 3. Identify and quantify the user population for the administrative task.
Task 4. Perform a functional analysis of the instructional and administrative tasks to be performed.
Task 5. Design a computing system to accomplish the instructional and administrative tasks, including selection of equipment types, manpower requirements, and administrative file structures.
Task 6. Develop preliminary system specifications and estimate system costs.
Task 7. Validate the preliminary system specifications.

SUMMARY OF RESULTS

Task 1--General System Requirements

These four general system requirements represent the first level of precision in defining the system:

Acceptability. The introduction of the system into the schools and colleges should cause an absolute minimum of disruption to current plans and programs in the instructional and administrative areas.

Responsiveness to Changes. A very large, diverse, and changing user population as typified by school and college students requires a system that can readily adapt to its changing needs.

Economic Practicality. The costs of the total system must be consistent with current and planned educational expenditures for innovative programs.

Operational Readiness and Efficiency. The system must be maintained in a high degree of operational readiness, commensurate with cost objectives. The system should handle the workload projected over the next five years with the highest possible efficiency.

Task 2--Instructional Users

Instructional users include both students and teachers in the areas of problem solving and DP training.

Problem Solving. Student users need computing services for problem-solving support, including computation, algorithm development, and simulation for physical experience and social science games in the following ways:

- "Conversational" access to the computer during normal school hours
- Courier service for transporting lower-priority student jobs to the central computer for overnight batch processing with the processed output transmitted back to the school via a school terminal

Teachers, curriculum specialists, and related members of the instructional staff need the same type of remote terminal services to support in-service teacher training, aid in preparation of lesson materials, and assist in classroom demonstrations.

For maximum student access and ease of communications with the computer for problem solving, the system should provide the facilities necessary to support a specialized problem-solving language that has the following characteristics:

- Rapid response to all entries
- Freedom from spacing restrictions on input
- Brief and self-explanatory error messages
- Easy correction of keystroke errors before transmission
- Easy data entry procedure
- Access to a common library of frequently used programs and functions
- Ability to save work-in-progress (at a subsequent session a student can begin where he left off previously)
- Protection against accidental destruction of saved files
- Simple terminal commands
- Easy recovery from any inadvertent error in terminal operation

DP Training. For data processing vocational training support, programs in card form should be entered into the computer via a card reader attached to a school administrative terminal or via courier service for at least overnight processing of programs. Conventional high-level language processors are available for the control computer. DP vocational training does not require the use of a remote terminal in an immediate interactive mode.

For DP familiarization training, little or no access to the system is required; computer demonstrations will satisfy the needs for this type of training.

Task 3--Administrative Users

Administrative users of the system include members of the boards of education, school administration, educational staff, clerical and service staff, and others. These users are grouped into five areas: the public users, the administrative center, the school office, the school staff, the student, and the parent. These users require access to large volumes of data. Generalized data management facilities are needed to allow individual users to input data and prepare reports according to their own specifications. Security locks are also needed to preserve the integrity of the data against unauthorized usage.

Task 4--Functional Task Analysis

Problem Solving. Conversational versus remote batch entry of the problem algorithm from the terminal were considered, with a review of the equipment and costs required for each. The conversational mode is the proposed method both from the standpoint of performance and cost.

DP Training. Choices involved the means by which student programs would be compiled and executed. Both remote terminal batch entry and central site entry of "jobs" were selected to accomplish this task.

Administrative. System functions to support administrative requirements are defined as a terminal-oriented school information system. Administrative tasks cannot be performed on a conventional application-by-application basis. All data wherever collected and wherever needed should be used as elements in a single integrated system. Such information should be collected close to the source only once; the system should accept such data in whatever form it is most conveniently available.

The requirements of a generalized system were reviewed, and a design preference was given to the Generalized Education Management System under development as part of the Oregon Total Information System.

Task 5--Definition of Computing System Equipment

The instructional and administrative terminals, the computer, and the shared use of communications lines by multiple terminals were defined in terms of equipment specifications. Administrative file structures for student, staff, fiscal, property, and curriculum files were also defined. Manpower requirements and preliminary cost estimates completed the effort on this task.

Task 6--Preliminary System Specification

General system specifications were written to meet the total requirements for instructional and administrative tasks and their projected workloads. The central processing unit, main storage, auxiliary storage, input/output controls and channels, communications control unit, programming systems, and remote terminals were defined, and detailed cost estimates were prepared for the USOE region, three IBM-defined regions, and an actual case study region. (The preliminary system specification is contained in Volume II.)

Task 7--System Validation

Validation techniques incorporated two elements: First, a real geographic region was selected in which to gather data; with the collected data a theoretical systems implementation for the area was postulated. The Washington, D.C. metropolitan area was selected as the closest to the headquarters of the study team. This area includes a great variety of characteristics, including two states and the District of Columbia, a mix of large and small school districts, and homogeneous and heterogeneous student populations.

A second element of the validation was to simulate the selected system for the four model regions and the case study region. The method employed used the Computer System Simulator available within the IBM Corporation. The simulator modeled the teleprocessing and multiprogramming environment of the proposed system, and by closely adhering to the step-by-step performance expected, the study team tested and evaluated the workload capabilities of the proposed system. Response times that would compare to real life were then determined.

After comparing intermediate simulation results with the performance of a live problem-solving system, the study team validated the system design.

CONCLUSIONS

1. A remote terminal centralized computer system serving a very large number of users simultaneously is entirely feasible, considering the total performance and price objectives. In addition, such a system serves extremely important educational needs that cannot be met otherwise. These needs must be met to adequately cope with the problems of the students as the nation approaches the 1970s.

2. The problem-solving capabilities of the system offer by far the greatest direct instructional benefit, and serve many more students than are served for DP training. The unique element in this conclusion was the identification of a requirement for a problem-solving language. This language is not a general purpose computer programming language, but a specialized methematical notation system that can be implemented for use in a conversational mode on a remote typewriter terminal. Only with this specialized capability can the computer system be designed on an efficient and economic basis. Furthermore, this capability eliminates the major barrier to widespread use of computing in the schools; namely, that courses in programming are prerequisite to the problem-solving experience.

3. For administration, a worthwhile contribution can be made in behalf of the entire operation of the district or regional groupings of districts by implementing a total schools information system, using terminals that were justified primarily for problem solving. Thereupon, a truly excellent computing system also becomes available for data processing training, and administrative work. Through shared use, not only can most needs of the users be met in total, but the financial savings which can be effected make the entire operation financially feasible.

4. Both performance and cost considerations have led to the selection of computer-controlled typewriters in the schools and colleges, with the addition of card reader and punch features to support administrative and data processing training tasks. Satellite computers or moderate-speed card readers and printers in schools and colleges were considered carefully, and met the technical requirements for the system. However, to provide these facilities to all institutions in the region would exceed cost objectives. Therefore, they were not included in the system designs. The system design architecture does accommodate these components, however, if funds are available in a particular implementation.

RECOMMENDATIONS

1. With respect to the grade levels to be served for instructional use, the desires of the USOE were observed in limiting these uses of the system to the high schools, with the most usage in grades 10 through 14. The study team concluded, that the problem-solving language has much applicability at lower levels, perhaps as low as grade 7.

2. With respect to the grade levels to be served by the administrative system, the study team concluded that it would be impossible to limit availability to high schools only, and that in fact an obligation exists to make advantageous use of the system in meeting the entire needs of the district, for all grades served without distinction. Thus, the administration needs for grades K through 14 should be met.

3. The study team recommends a follow-on detailed study and a pilot implementation of the system, in some one locality. This system should be subsidized at an appropriate level, and be implemented in a manner which will produce a generalized "package" that can subsequently be installed elsewhere. It is not necessary for each potential user of such a system to undertake a development program at each new location.

4. During the site visits, and later at a group presentation in Washington, D.C., many managers or directors of current data processing installations in schools "volunteered" their area as a pilot center. The interest is very great, and a large number of locations desire to be the first. The selection criteria for such a site are as follows:

   a. The area must include an appropriate mix of the types of schools, and of student populations, that would most likely be subject to all of the problems that will eventually occur. Here problems are desirable. It is much easier to deal with problem situations in the controlled environment of a pilot center than after the system is completely designed.
   b. The second site-selection criterion is the availability of money to pay for the cost of the development. Few school districts could finance such an effort without assistance. Even at the state level, funds are not available in sufficient amounts, for a long time, to adequately finance the required development effort.
   c. The third site-selection criterion is the availability of people to adequately staff the undertaking. Unique individuals are required for the system development

effect. They must be found and induced to work towards this goal, if a true implementation is ever to occur.

DEVIATIONS

1. The model regions projected assumed the presence of large junior colleges; those found in the case study area were also large. The needs for problem solving and data processing training were incorporated into the projected system for junior colleges, but the assumption was made that administrative tasks would not be performed by the system for junior colleges.

2. Five-minute turnaround time is provided for problem solving only. For DP training, the system provides reasonable access to the terminals, and overnight batch processing to accomplish the workload projections used in the study.

3. In addition to the model region defined by USOE, three other regions (A, B, C) were defined.

PART 2: SYSTEM DEFINITION

This part describes the considerations that led to a system definition for the problem solving, DP training, and administrative requirements. Each requirement is presented separately in terms of user requirements, workload, system requirements, and system definition.

PROBLEM SOLVING

Student Requirements

All students in mathematics, physics, chemistry, biology, and related academic subjects must be provided reasonable access to computer facilities:

1. To support problem-solving and computational experiences
2. To become knowledgeable about the application of computing techniques to appropriate scholastic tasks

"Reasonable access" as used for academic subject support was determined to be:

- Scheduled availability of computer services to the students in the "problem-solving" sessions of 20 minutes duration.
- Additional availability of conventional computer facilities in off-hours. "Conventional" facilities are defined as batched job input with sequential processing.
- Student/computer communications should not necessarily require an extensive knowledge of a conventional computer programming language, such as FORTRAN, COBOL or PL/I. Student attention should be placed on the problem-solving task itself, not on the computer-necessitated detail.

Teacher Requirements

Teachers and other members of the instructional staff must be provided the same reasonable access as the students to computer facilities:

1. To support in-service training
2. To assist in the preparation of lessons, exercises, and test materials
3. To enhance classroom demonstration in problem solving
4. To develop curriculums

WORKLOAD

Table 2 shows the courses taught in high school (grades 10-12) and junior college (grades 13-14) that are most likely to use the problem-solving capability in an initial implementation. An estimate of the percentage of students in each grade who would be taking those courses and the approximate number of problem sessions of 20 minutes each for a student or student team in each course during the school year are shown. This annual workload is the projection after the first five years of use.

The estimate of the number of problem sessions per year is based on an appraisal of the gradual implementation of a new technique in the secondary school program, and on the economics of school budgeting for this technique. During the first five years, there will be an accelerating growth of interest in computer-based problem solving as teachers acquire the experience and as the materials for instruction using this new tool become available. After five years, new demands on the system should evolve with experience, and future systems design features should be evolved to satisfy these demands. Because of the varying percentages of students enrolled in courses, and the varying level of activity, the estimates of total system usage are about equal for grades 10 and 11. Senior students in grade 12 will be fewer in number, but much more active. For example, many students taking biology in 10th grade will be light users of the system, but the few students taking calculus in the 12th grade will be heavy users of the system.

SYSTEM REQUIREMENTS

To satisfy the user requirements and workload for problem solving, the system must:

1. Allow students and teachers scheduled access during school hours to "instructional terminals" in the schools for problem-solving support. These terminals may communicate over common carrier facilities or private facilities with a modern high-speed computer.

   (Problem-solving support refers primarily to support of mathematical and scientific subjects, including computation, algorithm development, and simulation for experimenting with physical phenomena and gaming in the social and management sciences.)
2. Provide overnight service for processing lower-priority tasks. These tasks could include independent study assignments, extra-curricular activities (i.e. computer club), and selected homework problems. This would be accomplished through conventional batched job entry at the computer center site, followed by sequential processing, and transmission of the processed output back to a school terminal on a scheduled basis.

Table 2

PROBLEM SOLVING WORKLOAD

Grade	Course	Percent of Students in Grade (1)	Number of Problem Sessions/Year (2)
10	Geometry	40%	10
	Algebra I	20%	5
	Biology	80%	10
11	Elementary Functions	25%	20
	Algebra II	25%	10
	Chemistry	37%	10
12	Calculus	12%	30
	General Mathematics	12%	5
	Physics	25%	15
13, 14	Math A (Calculus)	10%	20
	Math B (Elementary Functions)	15%	15
	Math C (Basic Algebra, Trig)	25%	10
	Physical Science (Physics, Chemistry)	10%	15

[1] Based on data collected by the IBM study team and on the USOE Digest of Educational Statistics, 1966.
[2] Projected for the first five years of use based on estimates of curriculum consultants.

3. Support the students and teachers at the terminals by processing their tasks rapidly and efficiently in a conversational way. This support requires a problem-solving language implementation to ensure that the system will process the maximum number of jobs possible during the problem-solving session. This language must be sufficiently general so that the user can concentrate on the elements of problem definition and program formulation, rather than computer-oriented procedures.

SYSTEM DEFINITION

The preferred means of performing the problem-solving tasks is in conjunction with the remote terminal at the school. Normally, the student or groups of students will enter their own problems with an immediate response from the computer on a statement-by-statement basis. A teacher may also use the terminal for demonstration purposes in the classroom. The same immediate response will be provided. (Consideration was given to conversational versus remote batch entry for problem solving. Results of the comparison are in Appendix A.)

Conversational Mode

Each input statement is interpreted by the problem-solving language processor. Each statement is keyed in and diagnosed for syntax. If a syntactical error is found, an immediate diagnostic message is given to the student before the next statement is entered. In this manner, the student is aware of improper program formats before execution time.

The student enters data for execution, and results are immediately printed at the student terminal. If the student desires other iterations of the problem with different data, he keys in the new data, and immediately executes the problem again. The student continually observes the results of each problem execution. Advantages of the conversational mode for problem solving are as follows:

Immediacy of Response. Experience of secondary schools now using time-sharing systems indicates that the level of student interest in computer problem-solving is roughly inversely proportional to the response time in getting answers. It is questionable that the rapid interchange of problems and solutions can be duplicated by any batch system, even one having quick turnaround time. It is the quality of give and take that students appreciate.

Useful Work Accomplished. A student can do more useful work in a 20-minute period of conversational interaction with a computer because he can correct his errors immediately, change his data for testing his conclusions, and rerun his jobs immediately. (In batch mode, two or more compilations and executions are often required before the student has a program that runs correctly; additional runs are required if any data are changed.)

Directness of Approach. The conversational system does not require the user to learn an elaborate set of computer-oriented conventions to solve problems. It eliminates the need for keypunching or other offline preparation of problems. It enables the student to use the computer easily and quickly with a minimum of training.

Cost. The conversational system uses low-cost typewriter terminals without the card reader features required for batch mode. In addition, the cost of the central processor required for conversational mode is also less.

The Pierce Report (Computers in Higher Education, February 1967) gives a good summary of the rationale for a conversational system for problem solving:

> "On the basis of available data and experience we believe that the simple programming languages, convenient terminals and rapid access of time-sharing systems will lead to a faster growth rate and a more widespread use then with older batch-processing systems."

Problem-Solving Language

Implementation of the problem-solving language on a computer should be efficient, permitting a student to enter a problem, correct any errors, enter data, get results, and experiment with the problem using different data--all in one 20-minute session at the terminal. To accomplish this interaction, the system communicates with the student in a "conversational" way. The computer-based system accepts statements in the problem-solving language from the student and responds appropriately and immediately, on a statement-by-statement basis. If the student has made mistakes in logic or expression, the system tells him so, clearly and succinctly. The student is able to modify his problem statement immediately, and see the results of the modification at once. The problem-solving language should have the following characteristics:

1. Compatible Notation. Allows direct expression of problems in the notation and symbolism reflecting the problem; not a general purpose programming language.
2. Direct Expression. Allows direct expression of mathematical statements, describes functions, manipulates arithmetic and character-oriented data structures, and develops models of natural phenomena.
3. Ease of Learning. A knowledge of a standard high-level programming language, such as FORTRAN, COBOL, or PL/I, should not be a prerequisite of learning the language.
4. Ease of Use. None of the computing "housekeeping", such as definition of file sizes and formatting of input and output data records, should be required.
5. Algorithmic Representation. A facility for efficient development and representation of algorithms should be provided.
6. Computer Independence. The language and its notations should be useful to a user who has only a pencil and paper, as well as to the user who has access to the language as implemented on the computer.
7. General Applicability. The language should apply to the needs of all users through the introduction of selected language statements at appropriate curriculum points in the school career.

DATA PROCESSING TRAINING

Student Requirements

All students should have the opportunity to understand the use of computing systems in today's society. The same introductory course should form the basis for subsequent courses to train vocationally oriented students in business and scientific systems design and programming.

Students should have reasonable access to computer facilities to handle student-prepared programs that result from data processing vocational training courses. "Reasonable access" as used for data processing training courses has been determined to be as follows:

1. Scheduled availability of remote terminals for transmission of program data after school hours, to allow the student to enter prepared problems into the central computer system for processing in a sequential mode.

2. Additional availability of conventional computer facilities in off-hours; for example, for use with night classes conducted primarily for adults.

3. Availability of programming language processors to support the demonstration requirements of computer concept courses. For those courses which concentrate on a specific programming language, the appropriate language processor must be available.

Workload

Each of four courses that could be offered at both the secondary and junior college levels are shown in Table 3. The percentage of students in each grade has been projected separately for each level; however, the courses are identical. Topic outlines for the courses based on portions of a data processing curriculum developed for the Ontario Department of Education, Toronto, Canada, are contained in Appendix B.

System Requirements

In the Computer Concepts course, there is little contact with a computer; most classes will visit various computer centers to acquaint the students with the appearance and general functions of data processing equipment. Since little attempt is made to instruct Computer Concepts students in machine operations or programming techniques, no machine time is required other than that used for simple demonstrations.

Once computer concepts have been taught, course material becomes more specific so that the student can specialize in complex machine operations, programming, systems analysis, or installation management. In these courses, the computer is used to a greater extent, especially in the programming classes. Here the student writes increasingly difficult programs, using increasingly higher-level programming languages as he gains proficiency. Naturally, the less-experienced students tend to use greater amounts of computer time for assemblies and testing than do more-experienced programmers. The solution to the system definition to meet this need must satisfy the following requirements:

1. The student must be able to prepare his program in a direct, machine-sensible form, and must be able to make changes and corrections as he progresses.

Table 3

DATA PROCESSING TRAINING WORKLOAD

Grade	Course	Percent of Students in Grade	Number of Problems Assigned Per Year
Secondary Schools			
10,11,12	Computer Concepts	15%	4
11,12	Basic Programming	5%	6
12	Systems Design	1%	4
12	Business Systems Programming	1%	4
Junior Colleges			
13,14	Computer Concepts	15%	4
13,14	Basic Programming	10%	6
14	System Design	5%	4
14	Business Systems Programming	5%	4

2. The student must have access to the computer for both assembly and execution phases with no less than overnight turnaround times.

3. The compiler and operating system that control execution must provide maximum information to the student in the form of diagnostics to aid determination of nonperformance of the program.

System Definition

A first choice of equipment design to meet the requirements is to have enough individual computers so that each student can spend all the time necessary at his own machine.

A second choice is to have at least one computer physically present, with each student spending some time at the machine personally, but allowing a professional operator to process the remainder of the work.

A third choice is to have a computer present, but to have all work processed by the professional operator.

A fourth choice provides a computer located at another installation but accessible to the student via remote terminals. These terminals must be capable of job entry and execution as if the terminal itself were a computer system.

A fifth choice is to use a computer at some other location, sending all programs via a courier service. (Figure 1 shows the five choices graphically.)

(The terminal in the fourth choice may appear to be only an updated courier service technique. Yet experience in using remote terminals in this manner belies this observation; to the student, the terminal is his computer.)

Only in the training period of the programmer is hands-on experience appropriate. With the use of high-level languages, hands-on experience is no longer necessary. As a result, the system definition is a combination of the fourth and fifth choices.

Each school has an administrative terminal with an associated printer and card reader/punch. By sharing this terminal for administration and DP training and adding courier service to the computing center, students have reasonable access to the computer and adequate turnaround time.

Two methods may be used to process student problems.

In the first method, the students use the keypunch in an offline mode to prepare punched card programs and data decks. These decks are read by the card reader and transmitted via the terminal to the computing center during the early after-school hours before the last clerk has left the school office. At the computing center, student data is processed immediately or deferred. In either case, the processed output, including the same listing and results, is transmitted via the communication network to the terminal printer on an overnight basis. By using this procedure,

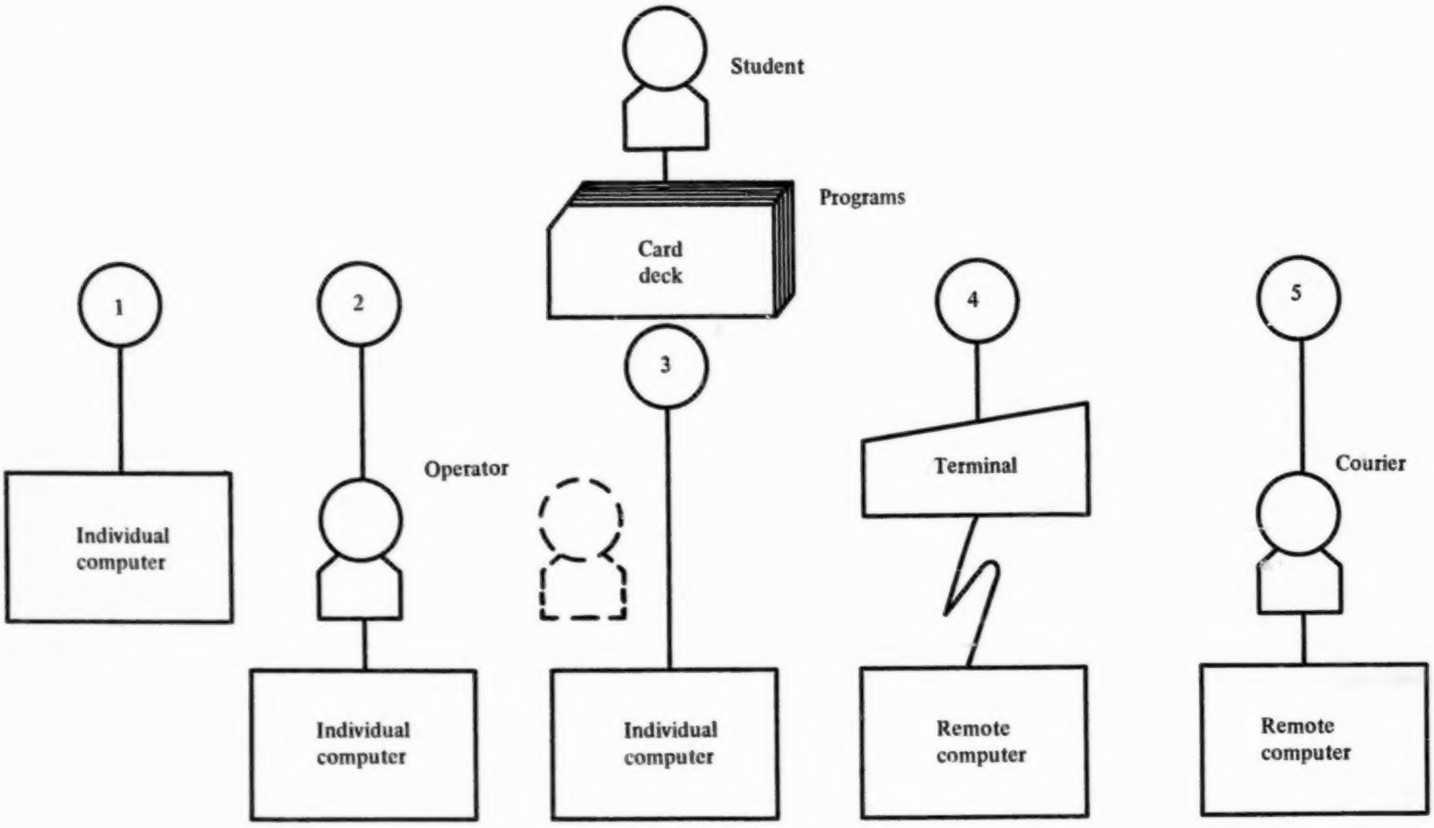


Figure 1. Methods for processing DP students' programs

programs completed in card form before the end of one school day are processed and returned before the start of the next school day.

For the second method, special forms designed to be marked in pencil and read by a special document-mark reader are used. The student marks the program and data characters on the sheet. The students' marked sheets are picked up by a courier at the end of the school day and taken to the computing center. At the computing center, the sheets are read by a document-mark reader and processed. Results are transmitted via the communications network to the school terminal printer before the start of the next school day. The marked forms are returned to the students by the courier on his scheduled pickup the next school day. The same courier technique may be used to handle cards punched on the offline keypunch connected to the administrative terminal. For larger or more advanced schools, additional keypunches may be needed to supplement the single keypunch associated with the school administrative terminal.

Figure 2 shows both methods described previously.

Program Preparation and Execution

A program is defined by the student, coded, and converted to machine-sensible form offline. Keypunches prepare problem statements on punched cards for input. (Experience shows that a typical student problem will average 25 input cards, the number used for this assumption.)

The terminal for batch entry consists of a keyboard/printer and card reader. Cards are read by the terminal and transmitted to the central site. At the central site, the programs are first compiled and then executed. Diagnostics do not occur until the compilation phase has begun. If a major error is encountered, the compilation aborts, and diagnostic messages are transmitted to the terminal and printed out. The student must correct the input statement in error offline, and the entire program must be reentered at the terminal.

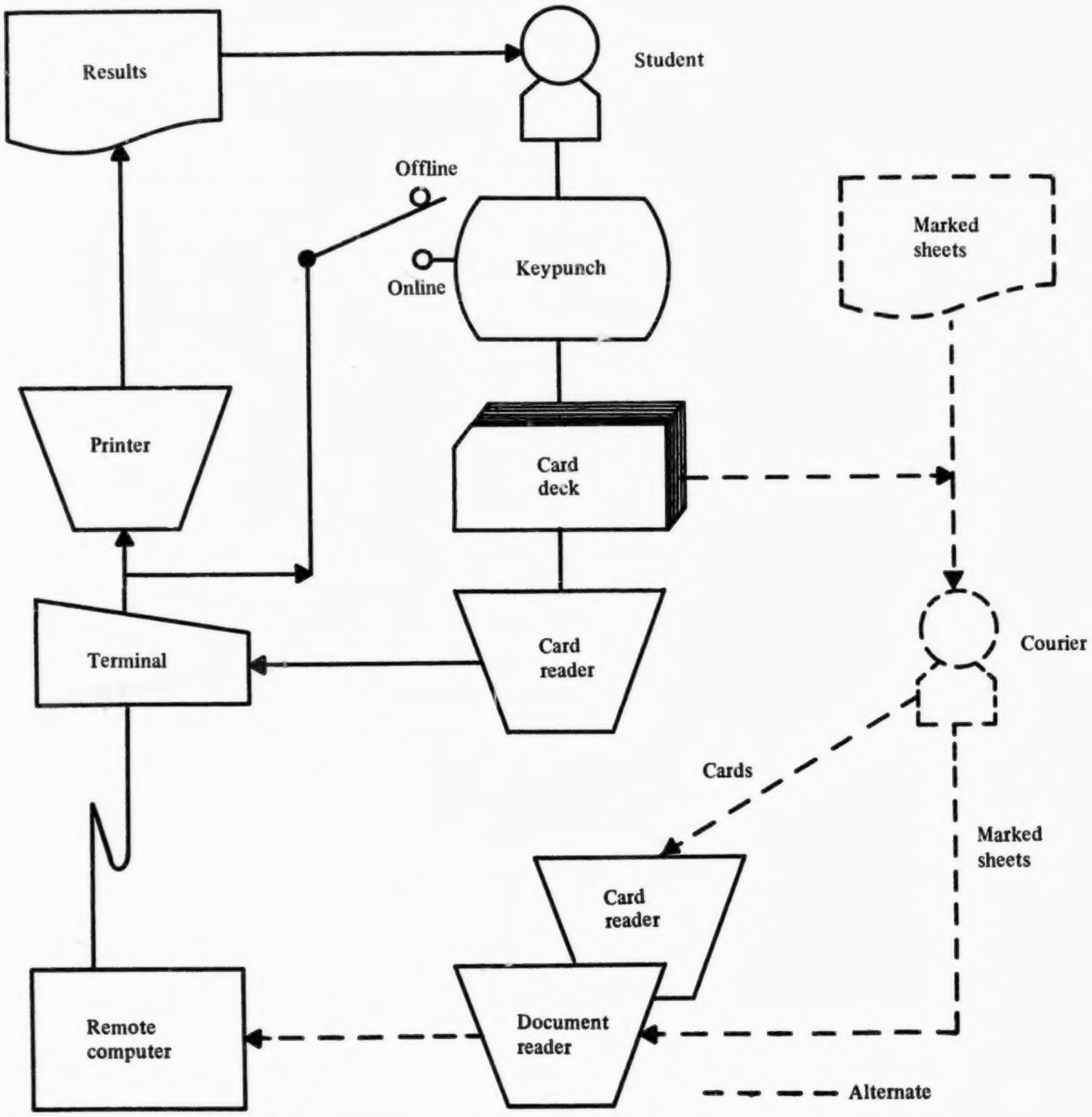


Figure 2. Selected method for processing DP students' programs

Experience with an efficient FORTRAN compiler specifically designed for student use was used for an analysis. With this compiler, a typical student problem requires approximately four seconds to compile and execute. The total terminal time is approximately four minutes per job. The output at the terminal consists of compilation diagnostics for any errors encountered and the results of the problem solution.

Language

Several levels of language exist and are in common use. The general terms used to distinguish between the major categories are "low-level" and "high-level".

A low-level language is one in which the program steps planned by the programmer are converted one for one into the assembled machine operations. The programmer, in effect, codes the problem using machine-type instructions. The language processor simplifies the task by performing dictionary construction of symbols used, substituting the hardware codes for the symbolic but, generally speaking, supplying no logic other than that coded by the programmer.

Examples of low-level languages are: S.P.S., Autocoder, Assembler Language, etc. Most manufacturers of computer hardware supply such languages under various titles with the software routines necessary to process the original program and define the hardware required to object-code the programs.

A high-level language is one in which the program steps are planned and written in a language not read directly by the machine. During compilation, prewritten routines called for by the programmer are assembled to accomplish the programmed task. There is no one-for-one relationship between the code supplied by the programmer and that compiled for use by the machine. Since the code of the programmer is designed to express the intended problem solution independent of the machine requirements, it is theoretically possible to construct compilers for the same source language program to operate on a number of different types of computers. In actual practice, this has been realized to some extent, but there are still some discrepancies between high-level language compilers supplied for different computers. Nevertheless, the differences are so slight that for a person who understands more than one compiler system, the time to make changes can be very little compared to the time it would take to recode the same problem using a low-level language.

Examples of high-level languages are FORTRAN, COBOL, and PL/I. At a minimum, the system should handle those languages which are standard in the industry, such as FORTRAN and COBOL.

Computer Simulator

For DP training it would be desirable to have a local computer for each school to use in a "hands-on" environment. However, local computers for all schools are impracticable from a standpoint of cost.

One way to provide a hands-on environment is through a simulated computer console typewriter. A simulation program can be prepared and stored in the common library. The simulation can give the hands-on feeling to the student, and permit him to trace the operation of his program within a simulated computer that registers type-outs at various critical points. If used with mural photographs of computer equipment, the feeling of being at a computer can be markedly heightened, since with the exception of the lights, there are no moving parts in the main frame of a computer.

ADMINISTRATION

Objectives

The computer system must respond to these general objectives for administrative users:

1. Help reduce clerical workloads of the teachers and members of the instructional staff, to allow greater concentration on student plans and programs.
2. Maintain extensive student records to assist teachers, counselors, curriculum specialists, and research staff in planning and evaluating programs for individual students.
3. Process high-priority administrative jobs during the hours of the normal school day, and process other jobs on an overnight basis.
4. Provide modern data management services to the school and central staff, including the following:
    a. Assistance in the acquisition, validity checking, and filing of all data pertinent to effective school management
    b. Rapid access for all information stored in the files
    c. Production of routine and special management reports in a meaningful and timely way
5. Provide support to all generally accepted student-oriented data processing tasks, such as student scheduling, attendance accounting, grade reporting, and student registration.

6. Provide support to the school business operations, particularly:
   - a. To provide complete and current budgetary and encumbrance information to administrative and operating divisions
   - b. To facilitate ordering and availability of supplies and equipment
   - c. To control growth of administrative and clerical costs to provide a greater share of funds for instructional use

Workload

Key tasks to be accomplished by the system to meet administrative requirements are listed below:

Student Administration. Registration, scheduling, attendance, grade reports, testing, locker assignments, counseling and guidance, funds accounting, receipt of district funds.

School Administration. Employee absences, audio-visual circulating materials, supply requisitions, budget control, purchase requisitions, parent/teacher organizations.

Central School Administration. Business services, budget control, program cost accounting, revenue accounting, budget preparation and projection, maintenance control, purchasing, audio visual selection-evaluation-scheduling, book order control, reporting to management, personnel control and payroll, planning and research, publications and information, curriculum development.

Figure 3 shows the data bank files used for instruction administration, business service, personnel, planning and research, publications and information, and curriculum development. Table 4 shows the Administrative workload.

System Requirements

Based on the foregoing user requirements, the remote terminal system must contain the following capabilities to provide the school information system functions:

1. Large-volume storage for school information within a centralized computer system.

2. Remote terminals in the schools and administrative sites to provide communications with the central computer.

3. Generalized data management and formatting facilities within the computing system to allow the authorized user to input data and obtain reports according to his own specifications. The computing system must provide security locks to preserve the integrity of the data against unauthorized users.

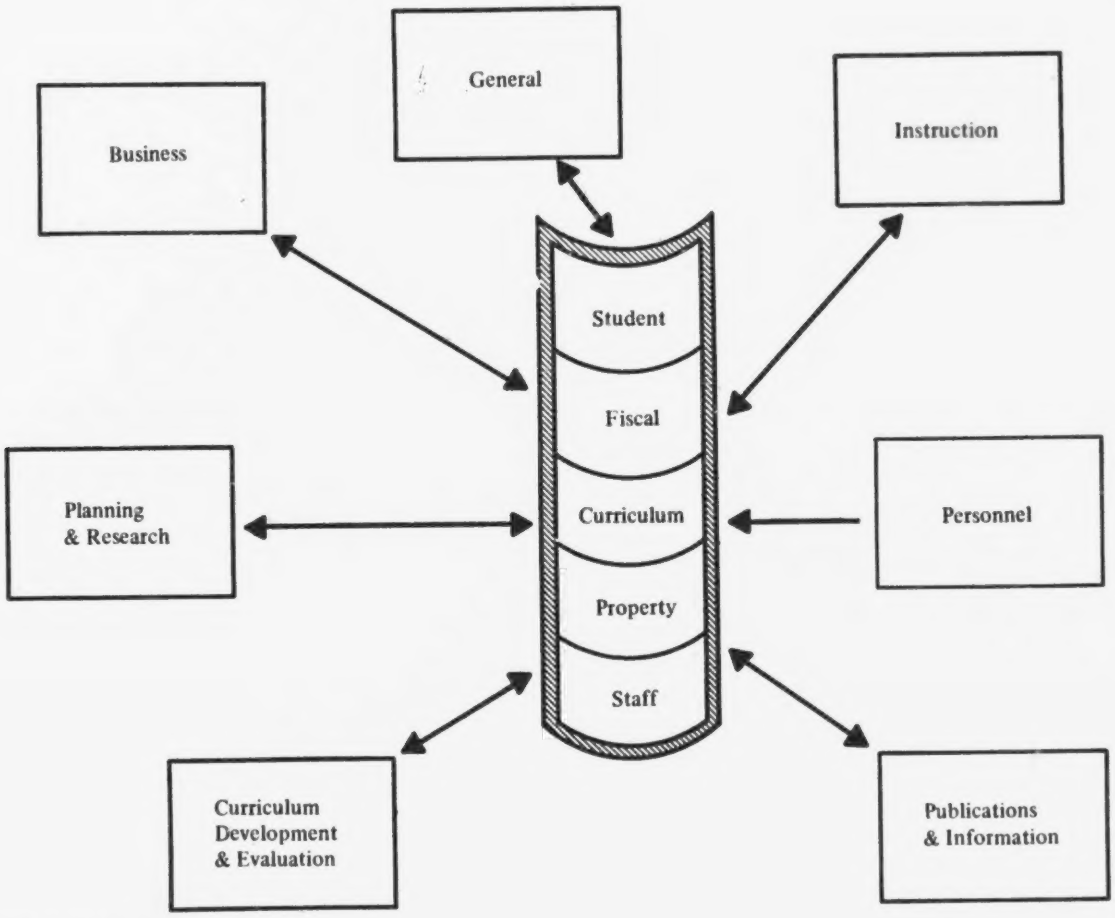


Figure 3. Administrative users of the intergrated data bank

Table 4

ADMINISTRATIVE WORKLOAD

Major Tasks & Master Files	Time Period	Master Files		Activity	
		Read	Write	Input	Output
Remote Entry Processing:	(volume per 1000 students)				
1. Attendance	Daily				
-Student File		200	200	200	200
2. Guidance	Daily				
-Student File		80	-	80	80
3. Registration	Daily				
-Student File	-	10	10	20	20
-Census File	-	10	10	-	-
-Class File	-	20	20	-	-
Major Batch Entry Tasks:	(volume per 1000 students)				
1. Student Processing					
-Attendance	Monthly				
Student File		1,000	1,000	-	1,000
-Report Cards	Quarterly				
Student File		1,000	1,000	200	2,000
-Student File Org.	Annual				
Student File		1,000	1,000	-	-
-Student Scheduling	Annual				
Student File		1,000	1,000	-	5,000
Course File		200	200	-	800
-Testing	Weekly				
Student File		-	-	1,000	2,000
-Census	Annual				
Central File		1,000	500	500	1,000
2. School Administration					
-Supplies Requisition	Weekly				
Supply File	-	50	50	50	50
Budget File	-	5	5	5	
Requisition File	-		5	50	50
-Budget	Weekly				
Budget File	-	30	-	-	30
	(volume per center)				
3. Central Administration					
-Enrollment Projection	Semi-				
Census File	Annual	25,000	-	-	
Student File	-	25,000	-	-	500
-Personnel Processing	Monthly				
Applicant File	-	120	60	60	180
Substitute File	-	600	600	600	600
Employee File	-	5,000	5,000	1,250	10,000
-Fiscal Operation	Monthly				
Budget File	-	6,000	2,500	3,500	10,000
Vendor File	-	2,000	1,000	2,000	2,000
Order File	-	500	500	500	1,000
Warrent File	-	350	350	350	1,050
Maintenance File	-	2,000	2,000	2,000	3,000
-Property	Monthly				
Audio-Visual File	-	1,000	1,000	200	1,000
Supply File	-	10,000	8,000	8,000	12,000

4. Terminals supporting procedures in the schools that provide for one-time collections of data to be stored in the central files and accessed by all authorized users.

5. Standard computer programming languages and library facilities within the central computer to support all routine administrative tasks, and generate periodic, exception, and on-request reports.

6. Sufficiently generalized to permit changes and differences in data, report formats, inquiries, etc., without reprogramming the entire system.

System Definition

School Information System

The recommended solution to the requirement of administrative data processing is a system comparable to the Generalized Educational Management System (GEMS), currently under development by Project OTIS, the Oregon Total Information System. This project is funded by the USOE, and is staffed in Eugene, Oregon.

The concept of GEMS was first implemented in the Advanced Medical Information System (AMIS) of the Veterans Administration Hospital in Washington, D.C. This system, with changes appropriate for use in the educational area, has evolved into the GEMS. Since GEMS was designed to meet administrative data processing requirements essentially identical to those required by the study and provides all of the generalized capabilities described in the previous subsection, GEMS is the preferred design choice for this system solution. However, it may be that other programming systems in development, of which the team is not aware, may provide a capability equivalent to GEMS. For this reason, the preliminary system specification describes only the functions to be performed by the system, and does not specify GEMS per se.

Administrative Center Terminal

Four typewriter terminals of average size will be required for the administrative center, located as follows:

1. Purchasing has need for rapid access to a terminal for quick reference when on the phone, or when answering personal inquiries. As a result, one of the terminals should be located within the purchasing department itself. In addition to being used for purchasing-originated inquiries, considerable quantity of copy will be produced by incoming supply requisitions from schools, etc.

2. Personnel has need for rapid access to a terminal for inquiries concerning employees, etc., originating internally and externally. In addition, because of the workload, it is necessary that a terminal be available for steady use in the updating of personnel files.

3. Depending upon local physical arrangements, the supply warehouse, maintenance office, operations office, and the audio-visual delivery center may normally share a common terminal in a mutually convenient location. Workload is such that if a choice must be made, it would probably be best to have the terminal in the maintenance office area, with pickup of copy for the supply warehouse if not convenient to the area.

4. The terminal for the budget control functions and the hard-copy terminal for payroll functions could be located in the accounting department. If a choice must be made, the workload would suggest that it should be located nearest the budget control section office.

School Terminal

For communication with the central computer site, a school administrative terminal with a printer and card reader/punch online will be required. After the school day ends and before the next school day begins, the terminal will be used for overnight batch processing as described under "Data Processing Training". It is also used for the problem-solving function.

Data Files

The five models defined for the administrative data files are Student, Staff, Fiscal, Property, and Curriculum. Each model is incorporated within the total information system, which in turn is subdivided into subsystems, each with its own files of data records. The data in any subsystem file can be used in conjunction with any other file, without regard to the model created by the data in the files. Collectively, they form an integrated data bank, as shown in Figure 4.

Each of the models within the system has certain typical files. Table 4 represents the types of files that might be available within the total system.

Most of the files shown in Table 5 are essential elements in a total information system. Some must be present in an initial implementation; others can be phased in one by one during the early stages of the implementation. By far the most critical file is the student file; the entire system is centered on the educational process.

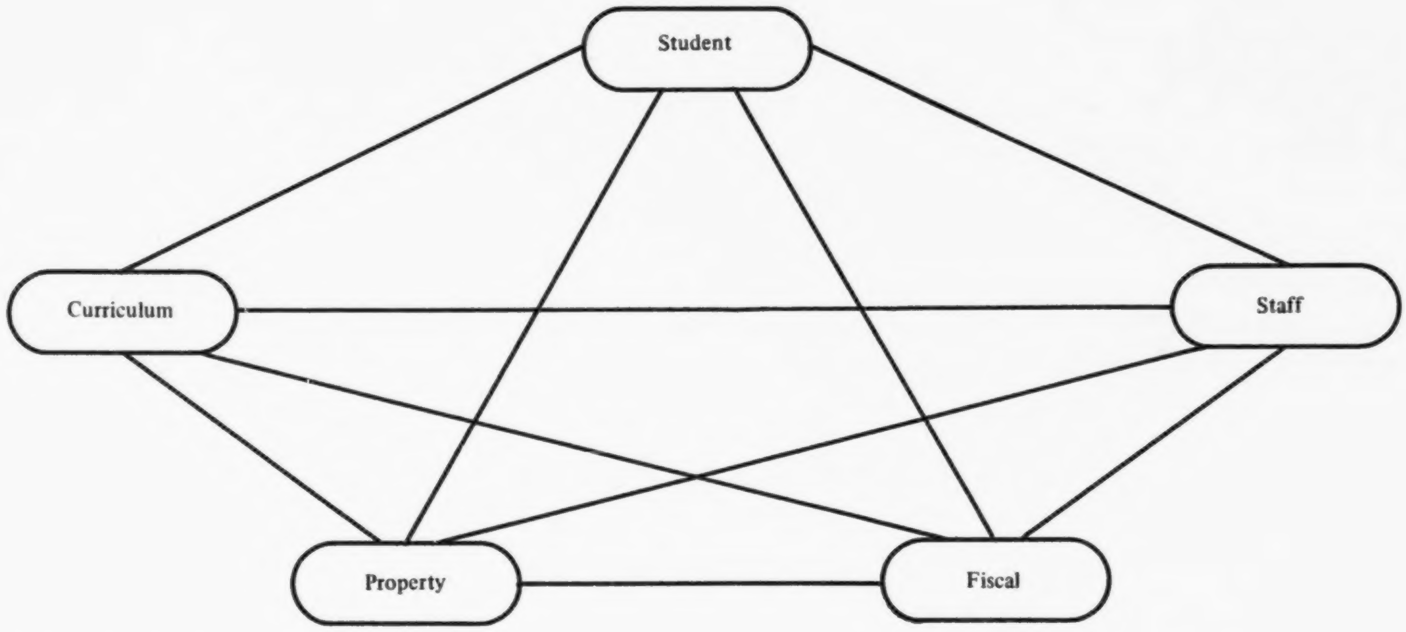


Figure 4. Integrated data bank

All files within the system are direct access because of the heavy emphasis upon real-time processing of data. Magnetic tape, however, may be used to record the status of the files at periodic intervals, for backup in the unlikely event of destruction of the main files. Magnetic tape also can be used to store transactions in the input stream, and to store the processed output records, if a failure in any part of the system makes it necessary to restart at some point.

Table 5

ADMINISTRATIVE FILE STRUCTURES

System Model	Subsystem File	File Sequence
Student	Student	Student Name Within School
	Demographic	Geographic coordinates
	Census	Residence Address within area
Staff	Applicants	Position applied for
	Substitutes	Position qualified for
	*Employees	Alphabetic by Employee Name
Fiscal	Payroll	Employee Number (Soc. Sec. Number)
	Budget/General Ledger	Account Code within Fund
	Vendor	Alpha by Vendor Name
	Purchase Orders	Encumbrance Reference Number
	Warrants Issued	Warrant Number
	Bdgt. Appropriations	Appropriations Reference Number
	Maintenance Jobs	Job Number
	Construction Projects	Project Number
Property**	Equipment	Inventory tag number
	Facilities	Location and type
	Library	Book Classification code
	Audio-Visual Materials	Catalog Number
	Educational Supplies	Catalog Number
	Maintenance Supplies	Catalog Number
	Cafeteria Supplies	Catalog Number
Curriculum	Courses	Course Code
	Classes	Section Number
	Test Item Bank	Classification Code
	Test Conversion Tables	Test and part code
	Test Scoring Keys	Test and part code
	CAI Units	Unit Code

Notes:

*Payroll data may be integrated into the Employee file where accounting control permits.

**Supply files in the property model may be used for inventories in a warehouse, or for ordering for direct purchase without distinction.

Many indices would be established not listed above, to permit reference of files through many different reference keys.

Detailed file layouts are shown in Appendix C.

PART 3: SYSTEM DESCRIPTION

This part describes the system configuration that meets the system defined in Part 2. System features, a currently feasible configuration, a future configuration, other computing center equipment, and manpower requirements are given in summary form. Volume II contains complete preliminary system specifications.

FEATURES

Figure 5 shows the equipment types selected by the study team to configure the remote terminal centralized computer system. It is an economic and efficient multiapplication computing system, serving a very large, dispersed user population. The system is designed to bring the power of current computer technology to the total user community, with the increased effectiveness and economies resulting from a large-scale facility. In addition, the system has the capability for efficient and simultaneous handling of a wide range of instructional and administrative jobs. With the availability of remote terminal facilities at the schools and colleges, the central computer system can provide services to a larger number of students in a wide range of disciplines.

Specifically, the system meets the general system requirements previously defined: acceptability, responsiveness to changes, economic practicality, operational readiness and efficiency. Features that match those requirements are as follows:

Acceptability

In the instructional area, services provided by the computer facility supplement the established curriculum. In the administrative area, transitional functions and data handling techniques of the system are reasonably compatible with the current administrative systems and procedures.

No net additional school personnel should be required at the individual school or college sites to operate or maintain the school-based equipment.

The remote terminals are capable of simple low-cost installation in the school buildings without any modification of existing plant, and occupy very little floor space.

Responsiveness to Changes

The system accommodates reasonable variations in workload because of changes in user population, course selections, curriculum materials, and administrative demands, without substantial system change.

When extensive workload changes occur, the system accommodates these changes without major system redesign effort or major disruption in the system operation.

The system automatically collects basic data on system utilization to assist operations management in improving the system, optimizing design selection for future growth, and measuring the services rendered.

Economic Practicality

The total cost for the operational system to service a population of secondary and junior college students is absolutely mimimal, consistent with the objectives of the users.

Operational Readiness and Efficiency

All computing equipment and programming system modules are provided from commercial product lines whenever possible. The equipment and programming systems meet industry conventions of reliability, maintainability, and operability.

Redundancy of equipment solely to improve the operational readiness is not required. Instead, arrangements may be made to obtain backup support on a service bureau basis for critical administrative jobs, in accordance with conventional computer operations.

Advanced but proven computer techniques and technology are used wherever possible to ensure the maximum system efficiency at the lowest possible cost. Techniques such as terminal "time-sharing" of the central processor, and data communications over common carrier facilities are a part of the design system. The system is capable of handling many tasks concurrently on a "multiprogrammed" basis to ensure that the system resources are utilized to the maximum possible extent.

CURRENT CONFIGURATION

Main Storage

The programs required to service a large number of terminals in a time-sharing system are large and complex, and require large memories when compared to single-use programs. The operating system is an essential requirement to permit a single computer to service many users, both concurrently, as in the case of terminals, and

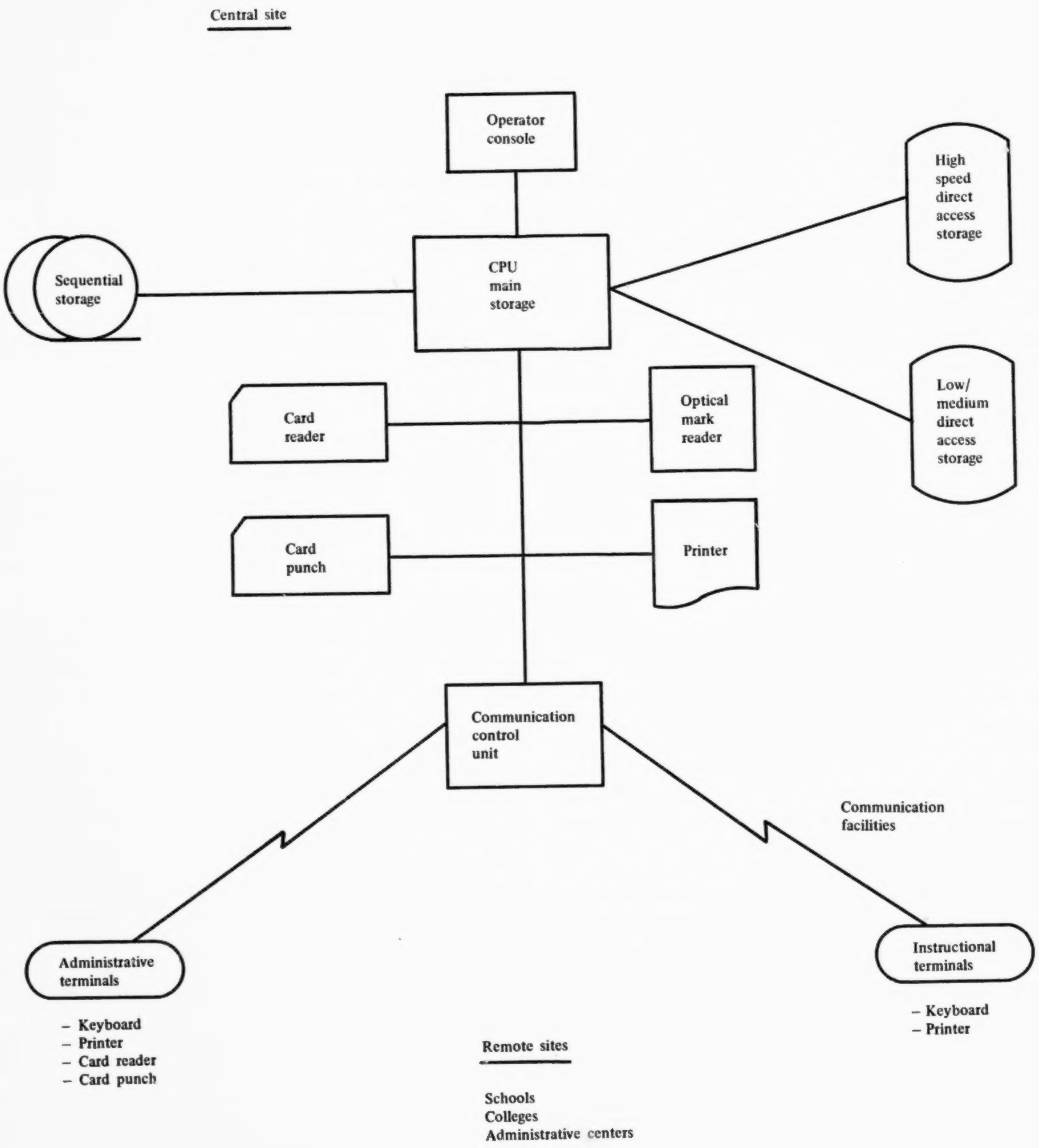

Central site
Operator console
High speed direct access storage
Sequential storage
CPU main storage
Card reader
Optical mark reader
Low/ medium direct access storage
Card punch
Printer
Communication control unit
Communication facilities
Administrative terminals
- Keyboard
- Printer
- Card reader
- Card punch
Instructional terminals
- Keyboard
- Printer
Remote sites
Schools
Colleges
Administrative centers

Figure 5. Equipment configuration

consecutively, as in the case of batch entry at the central computer site. Operating systems to perform these tasks are very large, and the probability is that they will get larger in the future, as they become more sophisticated in capabilities.

As a result of these factors, 256,000 characters of main storage is the minimum that should be provided in an initial implementation, with, perhaps, double that size eventually when the maximum volumes are being serviced.

Secondary Storage

Two types of secondary storage are available: magnetic tape for sequential storage of data, and direct access storage for random storage and retrieval.

Magnetic Tape Storage

Magnetic tape is used for recording sequentially all input and output transactions, and for transcribing the contents of direct access storage periodically ("dumping") for backup use in case of a system failure, but it is not used directly online for any active task.

Direct Access Storage

Two types of direct access storage devices are used: disk and cell. Each type differs in the total amount of storage capability, and in the speed with which stored data can be made available to the computer.

Disk Storage. Larger types of these units have very large numbers of disks, permanently mounted. Smaller types use disks containing from six to eleven platters per disk pack; the packs may be physically removed by the operator and replaced with packs containing different data.

Cell Storage. Data is magnetically recorded on plastic cards, which can be rapidly selected from a cell, wrapped around a rapidly revolving cylinder, and read as from the surface of a drum. Once read, the card is returned to its cell. A large number of cells are mounted on a rotating array, permitting the selection of the desired cell. Cells are easily removable, permitting a selection of cells suitable to the tasks being performed. (Although cell storage devices are considerably slower than disk devices, they have larger total storage capacities, and are cheaper per character stored than any other direct storage device.)

Card and Printer Devices

The fastest high-speed punched card input and output, and high-speed printer output capabilities are used. Typical speeds available are approximately 1000 cards per minute for the card reader, and 300 cards per minute for the card punch. Printer speeds range up to 1400 lines per minute, but should not go much under 1100 lines per minute as a minimum capability, to produce the output needed for large-volume centrally printed jobs, such as report cards.

Document Reader

The document reader reads 8-1/2x11 forms, on which a student marks with an ordinary pencil in spaces indicated on each form. Such marks, for example, are answers to test questions from standardized test booklets or teacher-made tests, or are used for batch entry of problems or programs done for homework where no terminal or keypunch is available. At least one such device, capable of reading such marks into the central computer, must be installed. As the volume of such work builds up, the requirement may build up to as many as four.

Instructional Terminals

The instructional terminal is a keyboard/printer resembling an ordinary office typewriter. It satisfies all requirements and is usable for many purposes in the school. The instructional terminal provides the same typewriter functions as the administrative terminal. Since the terminal will be used only in a conversational mode, the terminal has no card reader/punch components. Its only means of input is through a keyboard.

The keyboard provides the extended character set necessary for problem-solving. Since it also functions as an ordinary automatic electric typewriter in an offline mode, it has the capability to handle a character set modification to conform to the conventional typewriter upper/lower character set.

Since it is a low-speed manual entry device, the instructional terminal does not have the heavy-duty construction required for the administrative terminal. Thus, the instructional terminal should have a somewhat lower cost as compared to an equivalent administrative terminal without the card/read punch.

The normal use of the instructional terminal involves classroom demonstration use by the teacher, and student use on a scheduled basis. This terminal has the associated data-set for attachment to communications lines physically connected to the unit, all of which are mounted on casters. This data set terminates in a long cord with a phone jack. With casters, the terminal is taken from its normal location, wheeled into a classroom, and connected into a local phone jack. After the classroom need has ended, the terminal is wheeled back to its normal location where it can be used by students.

In addition to classroom and/or student use, certain administrative uses can also be accommodated on the same terminal. This terminal is well suited for inquiry and type-out of low-volume responses. For example, when not otherwise in use, counselors could use the terminals for student record inquiry, updating, and production of student records needed for student interviews. At certain times of the year, such as the opening of school, they might be exclusively used in this manner, since they would not yet be needed for instructional use. At other times of the year, such as at report-card time, they could be used, for example, by teachers for sending grades, comments, etc., to the central computer for use in preparing report cards.

Administrative Terminals

This terminal is a heavy-duty typewriter terminal that is connected to the central computer through common carrier facilities. The terminal contains a standard typewriter keyboard for data entry. A hard-copy typed output is available for all incoming or outgoing traffic. In addition to the typewriter component, an attached card reader accepts data in punched card format for transmission to the central computer, and an attached punch unit produces standard punched cards at the terminal under the control of the central computer. The terminal transmits and receives data at a rate comparable to the maximum typing speed of the typewriter (about 15 characters per second).

The typewriter portion of this terminal has multiple character set capabilities to support all administrative and instructional tasks. For problem solving or data processing training, sets with special characters satisfy the needs of the functions performed. For administrative uses, an all-capital-character set is available. The "home loop" or local use of the terminal as an automatic typewriter when using the card reader as the data source is available. The character set is exchangeable by the operator upon demand. (This must be a very simple and noncritical operation.)

The card punch component of the terminal prints the punched cards with easily readable alphabetic/ numeric characters across the top of the card. Since the punch will be used as an output of the terminal under computer control only at rare intervals, the punch provides normal keypunch services at other times. Since a keypunch is a necessary element to service both administrative and data processing training needs in the school, this device satisfies both the online card punch and offline punch requirements.

Since this terminal must support a heavy workload, all secondary schools, regardless of size, must have at least one administrative terminal with the card reader and card punch features. Manual keyboard entry cannot maintain the full-speed capabilities required of this terminal, nor can accuracy be guaranteed without visual verification before release of the data entered. Through use of a card reader, in fully-automatic mode or in conjunction with partial manual entry, an improved average input speed can be maintained, and accuracy is guaranteed where it is most critical. The additional throughput clearly justifies the added cost for the card reader and punch.

FUTURE CONFIGURATIONS

Central Computer

Functional differences in the central computer system between the first implementation and a future one will be minimal. The major differences pertain to capacity relative to workload. For example, a first implementation would service only a portion of the total user population. Yet all the demands on the system, other than volume, would be about the same. For this reason, a medium-scaled computer may be required initially, with a planned conversion to compatible computers of larger memory, secondary storage, and higher internal speeds, but not increased function capabilities. Thus, the computer programs, with minor exceptions (mostly to increase system capabilities, such as the number of incoming communication lines) would be the same for the initial and future system.

As the system size expands in the number of communication lines to be serviced, the internal high-speed memory of the computer may increase from 256,000 positions to as much as 512,000. In addition, as the total load on the system increases, the internal speed of the device will become more and more inadequate. At some point, usually about the time that more communication lines are required than can be physically attached, the computer itself will have to be upgraded to a higher model, with a faster internal speed. Before an actual implementation, it is difficult to estimate the exact point when an upgrade will be necessary. As a general axiom, however, the larger the computer, the lower the unit cost of performing a single operation. Thus, upgrading to a larger machine will in the end provide a greater economy per operation performed, even though the rental cost of the larger machine is greater.

Advancing technology will eventually require the replacement of the computer itself with a new generation computer. New technology will permit improvements in the price/performance ratios of new computers, and will perhaps bring improvements in the basic capabilities of the devices themselves.

Document Reader

At the present time, except for very sophisticated devices which require a constant high-volume load to justify, the only practical page reader within the school economic constraints reads the presence or absence of marks. Sophisticated devices are available, however, that can read both human-printed characters as well as machine-printed characters. Many type fonts can be read with these devices. With respect to handwriting, however, such devices usually limit the user to the numerics, and a few selected, printed, capital-letter alphabetics.

Communications Control Unit

Future technology may make it possible to increase the number of terminals which can share the use of a single line. The limiting factor for simultaneous transmission in either direction is the data bit capability of the line itself, compared to the data bit generation rate of the terminal use. Newer devices may become available that increase the number of terminals that can be serviced on a single line by temporarily storing the data from the terminal if the line is momentarily in use, and transmitting it during the next instant that the line is free. Thus, time that would otherwise be wasted on the line can be placed into use, with little or no noticeable effect upon the user. As educational television systems are installed in school districts or larger areas, technology may permit use of unused channel capacity for the two-way transmission of data.

Instructional Terminal

It is not expected that there will be a significant change in the design of the instructional terminal. While a display terminal could be considered, the lack of hard-copy output is a serious disadvantage to the student. A faster-rate printer would not be a significant benefit because of the small volume of output. As cost savings are achieved in the future because of improved technology, the increased buying power would probably be used to increase the number of such terminals, not to enhance their capabilities.

Administrative Terminal

In the future, the workload of certain schools may require hard-copy output that will exceed the rate possible to obtain from a low- or medium-speed terminal. To meet this requirement, it will be necessary to have a line-printer (line-by-line) capability at the terminal to replace the character-by-character output of a typewriter-output device.

The line printer should be able to print a standard, full-width form of approximately 120 characters wide, at a rate of approximately 100 lines per minute to justify the additional projected expense. An additional item of cost results from the necessity to use a high-speed communications line for such a terminal, because of the increased character rate necessary to maintain this speed.

Some of the administrative load in the future could be met through use of a visual display terminal. Currently, although they have some valuable capabilities, their cost exceeds the economic objectives for initial implementation. In the future, however, as the price of such terminals is reduced, and wherever hard copy is not an absolute requirement, these terminals should come into increased use, and are highly recommended. Naturally, since the requirement for hard copy from an administrative terminal is expected to remain, the display terminal would have to be considered as a supplement to the typewriter or line-printer terminal, to meet increased workload.

The visual display terminal is a cathode-ray television-type device, with a manual keyboard, essentially identical to that of a typewriter. As data is keyed in, the characters keyed appear on the face of a screen. Thus, all data entered on the keyboard is visible to the operator and available for correction before transmission to the computer, when released by the operator as correct.

At the present time, there are display terminals which meet all the above requirements, except that of low cost. For a first implementation, considering the cost objectives of this study, the display terminal cannot be recommended, even at an administrative center, where it can be best used. If adequate funds are available, however, this terminal can be well used in the administrative center. It is especially appropriate for use by the personnel department for examining and updating employee records, and for use in the control of school budgets.

There are many advantages to the display terminal. It can display a large amount of computer-generated text simultaneously, without the delays associated with the character-by-character production of a typewriter device or line-by-line printer. One of its most important features is its rapid edit capability. The operator corrects data by positioning a pointer under the data to be changed and then keying in the correct data. This action replaces the original data. The new data can then be quickly verified visually and released to the computer. The same ability applies to the initial entry of the data, or revision or deleting data.

The display terminal does not produce hard copy. For some administrative jobs, such as entering orders of supplies or obtaining budget balances, this would be a disadvantage, since a permanent record of the transaction should be maintained. For a guidance counselor, with a student seated before him in an interview, it would be an advantage. Significant portions of student record could be visible in a page-by-page fashion, easily accessed. Updates to the record could be made instantly by the counselor. Access to the computer files could be made rapidly and directly, with the user scanning large volumes of data in a browsing mode. For example, a student might be interested in examining college data for which his academic record would indicate a reasonable choice.

Data on each college could be displayed, one college at a time, with computer-generated annotations as to the student's probability of success, and what deficiencies, if any, would have to be overcome to improve chances of acceptance.

Over a period of years, technology improvements should not only bring down the cost of display terminals, but make them more flexible and adaptable. Current cabling requirements may be eliminated when a "stand-alone" display terminal is readily available on an economic basis. Some of the general objections with regard to eye-ease in using such a terminal over prolonged periods, will undoubtedly be eliminated with improvements in phosphors, display regeneration, and the matrixing method of generating characters. When the price/performance breakthroughs do occur for display terminals, they should be readily accepted by the administrative centers and the school counseling staff.

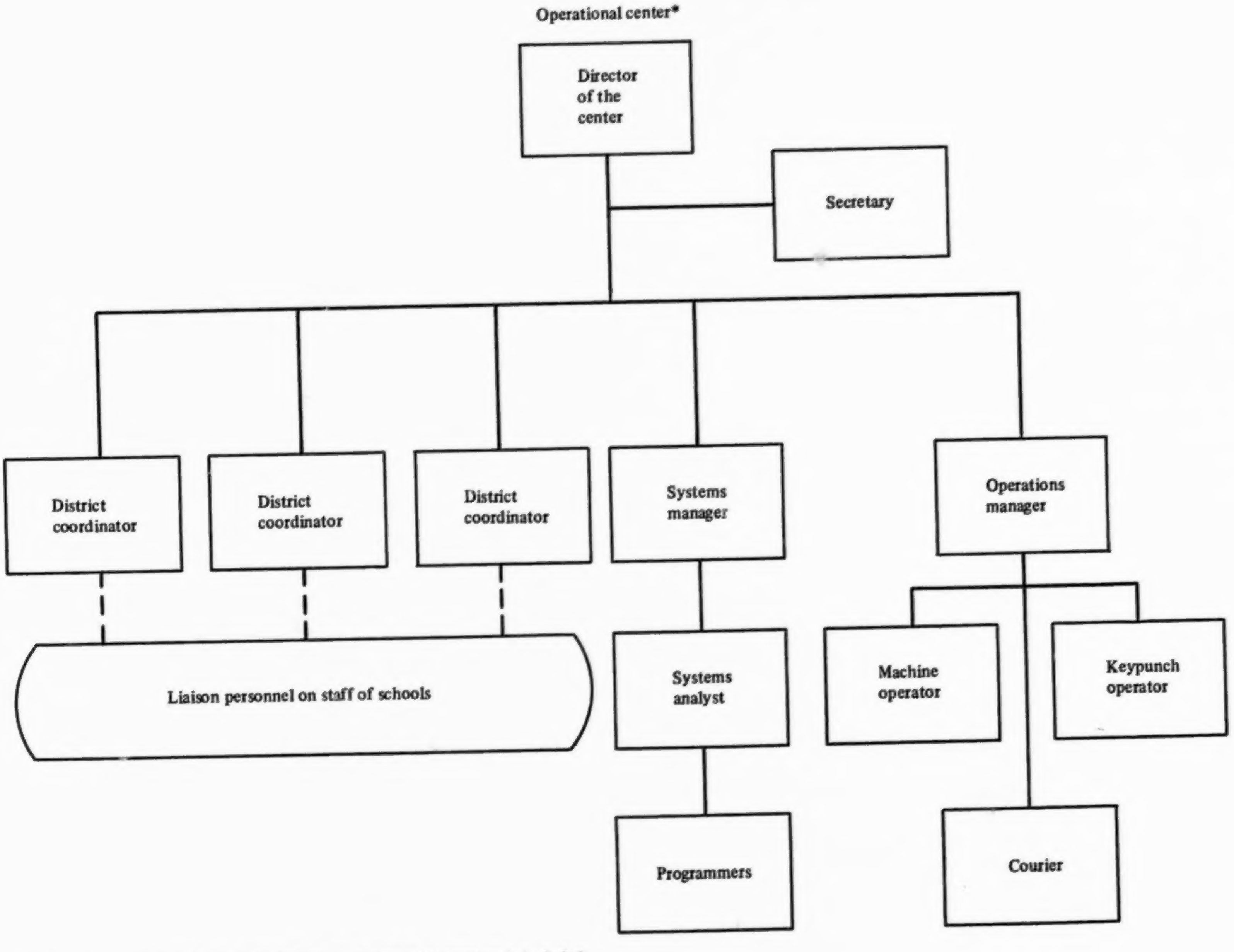
Send-only devices, such as touch-tone pads, have inherent problems of accurate verification. Such devices require blind keying, which is subject to human error, and must be caught quickly if ever to be fully satisfactory. While not as serious a problem, transmission errors because of noise in the phone circuits can occur, and must be detected. One possible means of immediate verification for such devices is voice-answerback under computer control. Because of the expense of this technology, however, it is not recommended for use in the proposed system at the present time.

OTHER COMPUTING CENTER EQUIPMENT

In addition to the central computer, and its attached devices, the usual array of auxiliary machines, such as keypunches and verifiers, sorters, interpreters, and perhaps collators, reproducers, etc., must be available. Extensive form-handling equipment to decollate carbon sets, burst the forms, and even insert report cards into envelopes, is also required. The computer center itself should be physically located to facilitate delivery and pickup, including perhaps a loading dock and adequate, close parking. Telephone facilities must also be planned and budgeted.

MANPOWER REQUIREMENTS

A computer center requires the usual complement of managerial and operational staff. Systems personnel are required to handle a continuing demand for doing new tasks, improving old ones, and maintaining present ones. In addition, there must be coordinators to act as liaison between the school and district users, and the center. Finally, there must be operators to run the machines and to do the clerical tasks required. Outside the computer center, there must be assignment of responsibilities for school staff personnel, to work with the coordinators. An example of a staff organizational chart for the center is shown in Figure 6.


Operational center*
Director of the center
Secretary
District coordinator
District coordinator
District coordinator
Systems manager
Operations manager
Liaison personnel on staff of schools
Systems analyst
Machine operator
Keypunch operator
Programmers
Courier

*No development staff for the initial implementation of the system is included.

Figure 6. Manpower requirements

PART 4: SYSTEM VALIDATION

This part describes the procedure used to validate the system configuration developed by the IBM study team. The effort involved the selection of a case study area to collect pertinent information on enrollment, workloads, and other statistics. On the basis of this data, equipment was selected and costs were projected. The equipment was then simulated as a system to determine its ability to handle the projected workloads for the case study region, the USOE region, and three regions (A, B, C) defined by IBM.

APPROACH

System validation involved two main areas:

1. A Case Study. An existing body of schools was selected to collect live data about the real world to evaluate school district sizes and machine costs.
2. A Simulation. The purpose of simulation was to simulate workload volumes and characteristics of the system to evaluate the technical feasibility of the system.

Case Study

Purpose

The case study was undertaken for five major reasons:

1. To produce realistic results, a simulation model requires input data that is representative of the live system being simulated. The model used for the initial phase of the feasibility study was theoretical and approximate. Real input data could be obtained only by selecting an existing body of schools, discovering their actual enrollments, and using these and other pertinent statistics in the simulation.
2. The experience in educational data processing today has been primarily in the administrative area. The instructional area is still largely speculative and experimental. No authoritative experience is available to determine how many terminals are required for problem solving in the schools. Only an intensive study of an actual school environment could establish the probable nature and extent of such needs.
3. The expense of a computer facility that can meet the needs of education today must be justifiable and feasible. The total cost of such a system could be estimated; however, to project approximate costs, it is necessary to know what is now being spent by school districts in a given area. With this information, costs were put into perspective, and the economic feasibility ascertained.
4. In a terminal-oriented system, line costs are an important factor in determining the total system cost. These expenses can be calculated only if the terminal locations, and the distances from terminal locations to central computer, are known. Arbitrary distances, assigned in a given radius, are not truly meaningful. Only a case study of an existing school system could provide realistic data.
5. A case study and simulation aids in proving that the findings of a feasibility study can be borne out in at least one true instance. Simulation is the only method of validation short of actual implementation. For these reasons, a case study of the real world was decided upon.

Data Collected

Four categories of data were collected. A brief description of their relevance to the validation effort follows:

Enrollment Information. Four types of enrollment data were collected:

1. The first was the total for K through 12 enrollment in each school district included in the study. This data helped to determine the administrative costs per pupil.
2. The names of all senior high schools and their enrollments, by grade, were collected. This data helped to determine the number of administrative terminals required in each school, and the peak loads on the computer for daily priority tasks.
3. The math/science course enrollment, by school, was collected. This data helped to determine how many problem-solving users there would be in each school and, thus, the number of instructional terminals required. (Math and science were assumed to be the courses most likely to utilize problem-solving capabilities in the immediate future.)
4. The names of all junior colleges, and their enrollments by grade and by course, were collected. This data helped to determine the number of instructional terminals required.

Course Information. The content of the courses offered by each district helped to determine the level of the courses and, thus, the degree of problem solving which would be used in each.

Since both titles and course content vary widely among districts, a catalog with course descriptions was used to obtain a true definition of the courses.

The objective of this analysis was to fit each course under one of the USOE math/science categories, calculate the enrollments, calculate the number of problem sessions on the terminal in each course, and then, as the ultimate goal, determine the number of terminals required by each school.

Geographic Information. Maps of each school district included in the study were used for spotting school locations. From this information, distances were derived, and the line costs of terminals were calculated.

Budget Information. The present operating costs of each school district were used to calculate the percentage of the budget that would represent the centralized computer facility. (The USOE Financial Accounting Handbook was used to describe the categories of the budget included in these operating expenses.)

Case Study Location

The case study area represented a reasonable cross section of the socio-economic population, as well as one that was near the study team location. The Washington, D.C. metropolitan area filled both qualifications.

The Central Atlantic Regional Education Lab (CAREL) located in Alexandria, Virginia, provided a great deal of assistance in determining which school districts in the D.C. metropolitan area should be included in the study. On the basis of approximate school enrollment figures and numbers of schools, the study area was selected to fit the USOE model as closely as possible. The six districts included in the study were:

District of Columbia
Montgomery County, Maryland
Fairfax County, Virginia
Falls Church, Virginia
Alexandria, Virginia
Arlington County, Virginia

Results

The objective of the case study was to take the conclusions of the feasibility study, supply data from an existing school system, and test the results. The following charts and tables describe the case study area and the results in terms of critical load volumes, equipment selection, and cost estimates and analysis. The assumptions and characteristics of the system design previously discussed were used as the framework for the case study. For example, the instructional use of the system is by senior high schools and junior colleges; and the administrative functions serve grades K-12, exclusively.

Enrollments and budgets for the school districts are based on 1966-67 figures. According to these figures, the average dollar amount spent per pupil in the total study area was $602.00 in 1966-67.

Population Table. Table 6 lists the districts included in the study; junior colleges are listed separately under the counties in which they are located. The number of schools and campuses are given, the enrollments, and the number of administrative centers, with totals for all categories. The total problem-solving enrollment for the area (senior high's and junior colleges) is 93,383. Total enrollment for administrative area to be served (K-12) was 404,642.

A map of the senior high schools, district administrative centers, and junior colleges located in the case study is shown in Figure 7. The numerals in each figure are the number of terminals projected for that location. Circles represent senior high schools; circled triangles represent district administrative centers; rectangles represent junior/community colleges.

The starred figure is the "named" location for the computer center. This location was determined by giving each spot an x,y coordinate on the map and calculating the most logical position (least average miles per terminal from each location). These results were then adjusted according to line costs in the Washington, D.C. metropolitan area. It is a theoretical computer center, but it fixes the best "area" in which such a center should be located.

Workload Tables. Tables 7 and 8 give the instructional workloads based on course enrollment statistics collected in the math/science areas from each school included in the case study. Calculations were made by using the number of problems estimated per course category. For secondary schools, the number of problem-solving sessions was derived from the following formula: 80% of the students do their problems in paired sessions; the remaining 20% work individually. For junior colleges, the number of problem-solving sessions is based upon individual sessions at the terminal.

The tables also include the daily priority pupil-administrative report workloads. These are based on total enrollments in each school, and estimated daily volume in attendance, guidance, and registration. "Daily Transactions" refers only to those

Table 6

POPULATION TABLE

District or Junior College	Sr. High Schools	District K-12 Enrollments			Adm. Centers	Junior Colleges	
		9/10-12	K-8/9	TOTAL		No. Campuses	Enrollment
District of Columbia	11	18,855	124,199	143,054	1		
Fairfax	17	30,195	71,224	101,419	1		
N. Va. Community Coll.						1	3,200
Falls Church	1	710	1,422	2,132	1		
Alexandria	3	4,768	11,433	16,211	1		
Arlington	3	6,114	20,031	26,145	1		
Montgomery	17	25,525	90,156	115,681	1		
Montgomery J. C.						2	4,016
TOTALS	52	86,167	318,475	404,642	6	3	7,216

transactions occurring after the first period of the day, and continuing through the last period. It is assumed that the bulk of these transactions will be performed during the first period (when problem solving is not in session) or after the regular school day. Since the critical period for administrative work is during the day, when the instructional traffic is heaviest, the daily workloads were considered most important. On the basis of these workloads, the number of terminals was ascertained. Table 8 shows the number of instructional terminals and administrative terminals. In school locations, problem solving takes priority over administrative work on both instructional and administrative terminals during the "problem solving" day. Only during the first period of school and after school hours will the administrative terminal be used exclusively for administrative functions.

In the district administrative centers only, the administrative terminals are dedicated, full time, to administration.

In the summary table, Table 7, the center terminal represents the number of administrative terminals in each district administrative center.

The data processing training workloads could not be determined in a realistic way, because none of the secondary schools presently incorporate a comprehensive DP training program in their curriculum. For these reasons, no data processing training workloads are included in the tables. Since most of the workload in this area should be in the remote batch entry mode, terminal requirements will not be significantly affected.

Cost Estimates. The summary cost data is presented in Table 9, with detail cost data in Appendix E. These costs are based upon the same assumptions utilized to compute costs for the four model regions set forth in "System Costs", with the following exceptions:

1. Equipment Selection. Table 10 shows the characteristics of the equipment costed for the case study region.
2. Communication Equipment. Common carrier costs for the communications support are based upon the representative tariffs for full-time leased facilities in the Washington, D. C. area. These tariffs are described in Table 11. Airline mileage between the remote location and the central site in northwest Washington, D. C. was estimated from area maps.
3. Personnel and Supplies. Estimated annual costs for personnel and supplies are those as specified for model region B in "System Costs".

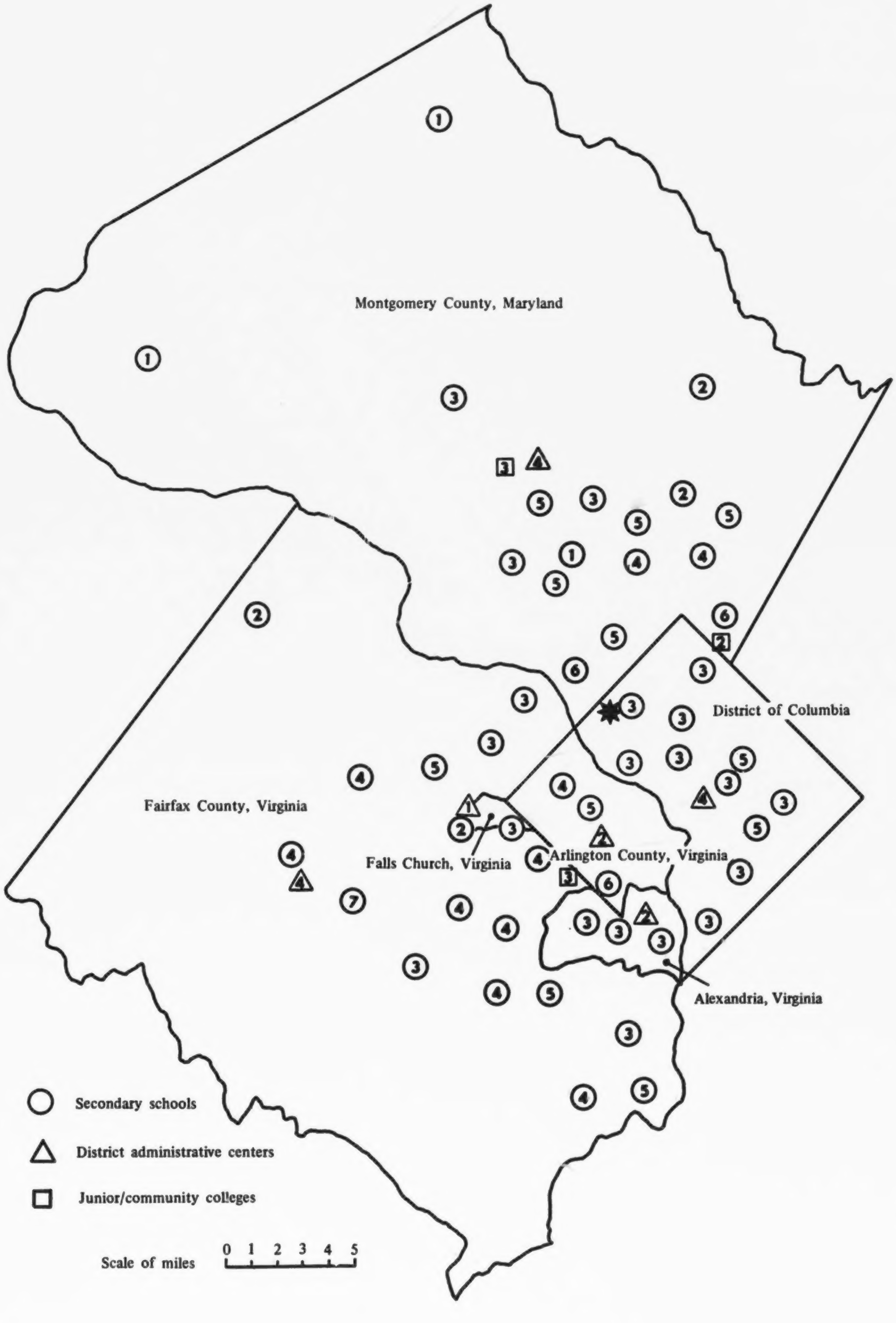

Montgomery County, Maryland
District of Columbia
Fairfax County, Virginia
Falls Church, Virginia
Arlington County, Virginia
Alexandria, Virginia
Secondary schools
District administrative centers
Junior/community colleges
Scale of miles
0 1 2 3 4 5

Figure 7. Case study area map

Table 7

WORKLOAD SUMMARY

District or Junior College	No. Sr. High's or Campuses	Enrollments			No. Adm. Centers	*No. Terminals			Terminal Totals
		9/10-12	K-8/9	Total (or 13-14)		IT	AT	CT	
District of Columbia	11	18,855	124,199	143,054	1	26	11	4	41
Fairfax	17	30,195	71,224	101,419	1	50	17	4	71
N. Va. Community C.	1	-	-	3,200	-	3	-	-	3
Falls Church	1	710	1,422	2,132	1	1	1	1	3
Alexandria	3	4,768	11,433	16,211	1	6	3	2	11
Arlington	3	6,114	20,031	26,145	1	12	3	2	17
Montgomery	17	25,525	90,156	115,681	1	44	17	4	65
Montgomery J. C.	2	-	-	4,016	-	5	-	-	5
TOTALS	55	86,167	318,475	411,858	6	147	52	17	216

*IT = Instructional Terminal
AT = Administrative/Instructional Terminal
CT = Center Terminal (District Administrative Centers)

Table 8

WORKLOAD

School	Enrollment	Annual Problem-Solving Sessions	Terminal* Requirements		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
District of Columbia							
Anacostia	1,569	7,467	2	1	346	32	44
Ballou	1,474	7,989	2	1	324	30	42
Cardozo	1,791	10,818	2	1	394	36	50
Coolidge	1,653	10,785	2	1	364	34	46
Dunbar	1,514	7,944	2	1	334	30	42
Eastern	2,576	15,006	4	1	566	52	72
McKinley	2,293	14,358	4		504	46	64
Roosevelt	1,518	9,030	2	1	334	30	42
Spingarn	1,675	9,114	2	1	368	34	46
Western	1,379	9,396	2	1	304	28	38
Wilson	1,413	10,359	2	1	310	28	40
TOTALS	18,855	112,446	26	11	4,148	380	526
Fairfax County							
Annandale	2,009	13,955	3	1	442	40	56
Edison	2,177	14,535	4	1	478	44	60
Fairfax	1,852	12,324	3	1	408	38	51
Falls Church	1,539	10,296	2	1	338	30	43
Fort Hunt	2,246	14,040	4	1	494	44	62
Groveton	1,324	8,892	2	1	292	26	37
Herndon	737	4,845	1	1	162	14	20
Jefferson	1,608	10,704	3	1	354	32	45
Langley	1,379	9,093	2	1	304	28	38
Lee	1,575	10,509	3	1	346	32	44
Madison	2,009	13,125	3	1	442	40	56
Marshall	2,281	15,691	4	1	502	46	63
McLean	1,401	9,495	2	1	308	28	39
Mt. Vernon	1,694	11,319	3	1	372	34	47
Stuart	1,899	13,020	3	1	418	38	53
W. Springfield	1,190	7,092	2	1	262	24	33
Woodson	3,275	22,185	6	1	720	66	91
TOTALS	30,195	201,160	50	17	6,642	544	838

* IT = Instructional Terminal
AT = Administrative/Instructional Terminal

Table 8 (cont.)

School	Enrollment	Annual Problem-Solving Sessions	Terminal* Requirements		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
Falls Church							
George Mason	1,085	5,571	1	1	238	21	30
TOTALS	1,085	5,571	1	1	238	21	30
Alexandria							
T. C. Williams	1,789	9,804	2	1	394	36	50
F. Hammon	1,469	8,304	2	1	324	30	42
G. Washington	1,510	8,556	2	1	332	30	42
TOTALS	4,768	23,328	6	3	1,050	96	134
Arlington							
Wakefield	2,553	18,495	5	1	562	52	72
Washington-Lee	2,042	15,258	4	1	450	40	58
Yorktown	1,519	12,963	3	1	334	30	42
TOTALS	6,114	45,419	12	3	1,346	122	172
Montgomery County							
Bethesda - Chevy Chase	1,860	15,516	4	1	410	38	52
Walt Whitman	2,065	21,138	5	1	454	42	58
Gaithersburg	1,520	7,878	2	1	334	30	42
Poolesville	505	1,320	-	1	112	10	14
Damascus	865	2,382	-	1	190	18	24
Peary	1,792	10,125	2	1	394	36	50
Montgomery	2,008	16,224	4	1	442	40	56
Einstein	1,558	11,406	3	1	342	32	44
Springbrook	1,864	15,015	4	1	410	38	52
Northwood	1,770	13,296	3	1	390	36	50
Montgomery-Blair	2,340	18,399	5	1	514	46	66
W. Johnson	1,940	17,877	4	1	426	38	54
C. W. Woodward	1,058	2,754	-	1	232	22	30
Wheaton	2,147	15,336	4	1	472	24	60
Churchill	1,288	7,173	2	1	284	26	36
Kennedy	858	4,881	1	1	188	18	24
Sherwood	1,390	4,692	1	1	306	28	38
TOTALS	26,828	185,412	44	17	5,900	522	750

* IT = Instructional Terminal
AT = Administrative/Instructional Terminal

Table 8 (cont.)

School	Enrollment	Annual Problem-Solving Sessions	Terminal* Requirements		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
Junior Colleges							
N. Virginia C. C.	3,200	12,435	3	-	-	-	-
Montgomery-Rockville	2,356	12,160	3	-	-	-	-
Montgomery-Tacoma Park	1,660	7,360	2	-	-	-	-
TOTALS	7,216	31,955	8	-	-	-	-
Administrative Centers							
D. C.			-	4	All Administrative Services		
Fairfax			-	4	All Administrative Services		
Falls Church			-	1	All Administrative Services		
Alexandria			-	2	All Administrative Services		
Arlington			-	2	All Administrative Services		
Montgomery			-	4	All Administrative Services		
TOTALS			8	17			

* IT = Instructional Terminal
AT = Administrative/Instructional Terminal

Table 9

SUMMARY ANNUAL COST ESTIMATES

Item	Case Study Region Cost
RTCCS COSTS	
-Equipment	
• Central Computer Site	$ 525,003
• Remote Locations	469,066
-Personnel	222,000
-Supplies and Unit Record	30,000
TOTAL	1,246,069
TOTAL REGION OPERATING EXPENSE	247,018,448
% RTCCS COSTS OF OPERATING EXPENSE	.50%
ADMINISTRATIVE COSTS ASSIGNED	704,811
INSTRUCTIONAL COSTS ASSIGNED	548,038

Table 10

EQUIPMENT SELECTION

Item	No.
Central Site	
-- CPU Main Storage (characters)	256,000
-- Direct Access Storage (characters)	
• High Speed	230,000,000
• Low/Medium Speed	400,000,000
-- Sequential Storage	
• (No. of Magnetic Tape Units)	2
-- Card Input/Output	
• (No. of Card-read-punch Units	1 Read 1,000 cpm Punch 300 cpm
-- Printer	
• (No. and speed in lines/min.)	1 Print 1,100 lpm
-- Optical Mark Reader	3
-- Communication Control Unit	
• (No. of Control lines)	
Local Monitor Terminal	1
Secondary Schools	191
Junior Colleges	8
Administrative Center	17
TOTAL	217
-- Communication Terminations	
• Common Carrier	2
• DP Mfg. Adapter	214
-- Average Monthly Usage (hours)	
• Summer (3 months)	176 hours
• School Year (9 months)	300 hours

Item	No.
Secondary School	
-- Number of Schools	52
-- Instructional Terminals	139
-- Administrative Terminals	52
TOTAL	191
-- Communication Network	
• Single Communication Lines	2
• Shared Communication Lines	65
TOTAL	67
-- Communication Terminations	
• Common Carrier	2
• DP Mfg. Adapter	189
Junior College	
-- Number of Schools	3
-- Instructional Terminals	8
-- Communication Network	
• Shared Communication Lines	3
-- Communication Terminations	
• DP Mfg. Adapter	8
Administrative Center	
-- Number of Centers	6
-- Printer/Keyboard Terminals	17
-- Communication Network	
• Shared Communication Lines	6
-- Communication Terminations	
• DP Mfg. Adapter	17

Table 11

COMMON CARRIER CHARGES--CASE STUDY REGION

Item	Monthly Charges
150 BPS LEASED LINE	
• Channel Arrangement--Central Site	None
• Channel Arrangement--Remote Site	
District of Columbia	None
Maryland	8.25
Virginia	8.25
• Station Arrangement--Central Site	25.00
• Station Arrangement--Remote Site	
District of Columbia	25.00
Maryland	25.00
Virginia	25.00
• Line Costs/per mile	1.75
VOICE-GRADE LINE (Share up to four subchannels with DP Mfg. shared-line adapters)	
• Channel Terminal--Central Site	None
• Channel Terminal--Remote Site	
District of Columbia	None
Maryland	7.50 (First Channel)
Maryland	5.00 (Each Additional Channel)
Virginia	7.50 (First Channel only charged)
• Line Costs/per mile	3.00

Budget amounts reported in Appendix E for the school districts include annual operating expenses only. Capital outlay is excluded. The cost analysis which follows these budget figures uses the same criteria as described in "System Costs", to distribute the costs of instructional and administrative use. The estimated value of administrative data processing services was first computed. This value is based on the experience of typical school systems around the nation, as explained in detail in "System Costs". The instructional cost is the net cost remaining, and is distributed to secondary schools and junior colleges on the basis of their percentage of total workload. The cost per student is determined from secondary school and junior college enrollments.

Two types of communication line costs were calculated for each location, using the figures in Table 11. The lower of the two resulting amounts was used in each case.

Simulation

The objective of the simulation task was to predict the performance of the selected equipment and programming system configurations. Since time did not permit the simulation of the total system activity, the simulation effort was directed towards modeling that period during which the critical time-dependent tasks must be processed. These critical tasks include the student remote terminal problem-solving session and major daily administrative tasks, which require remote terminal entry and priority processing during the normal school day.

To accomplish the simulation task, a detailed algorithmic model of each configuration was developed and programmed. This model was then used in two ways:

First, simulation runs were made with a preliminary systems design, using the workload and model regions. These runs provided detailed data on system performance characteristics that pointed the way to design improvements. These design improvements were then incorporated in the model, and further simulation runs were made. This process was repeated until a system was evolved which met all major system requirements.

Second, after a feasible system was developed to handle one model region and its workload, the same design/simulation process was repeated to develop additional systems to handle other model regions, both smaller and larger. This process was utilized to establish the major equipment and programming system specifications contained in Volume II.

Finally, the live data collected for the Washington, D.C. metropolitan area case study were utilized for simulating the equipment requirements for this region. The remote problem-solving language portion for the simulation was validated by successfully simulating an existing problem-solving language implemented on an IBM System/360 at the IBM Research Center in Yorktown Heights, New York. The parameters for the operating system were derived from the IBM Disk Operating System/360; these parameters included the estimated overhead times associated with each of the DOS/360 tasks. The model was validated to the point where all contention for, and utilization of, system resources was accurately simulated. This validation represents an unusual occurrence in the simulation of complex computing systems, wherein a live system provided a direct validation of the basic model.

Upon completion of the model validation, the model was adjusted to reflect the characteristics applicable to the school environment.

System Operation

Figure 8 shows the system components which were simulated to obtain peak load performance on the problem-solving and administrative applications. Appendix F shows the exact simulator configurations by model region.

Students use both the Type 2741 and Type 1050 terminals for problem solving, which consists of student requests entered from the keyboard, followed by computer responses typed on the printer. Each student is assigned one or more 18,000-byte workspaces, which are stored in a library on disk. A time-sharing algorithm is used so that it appears that each terminal has exclusive use of the CPU, with average response times less than three seconds. The currently active workspaces are swapped back and forth between core and disk as required.

Problem solving is given first priority in order to achieve the fast response times required. When there are no active student workspaces available in core to be processed, administrative inquiries are handled until the next interrupt occurs. These inquiries are sent in from the 1050 keyboards or card readers, and responses are returned to the terminal printers or card punches. The average response time for high-priority inquiries is less than two minutes, and low-priority inquiries are queued for overnight processing if they cannot be handled during the day.

Appendix F contains a description of the problem-solving and administrative models used in the simulator, plus logical flowcharts.

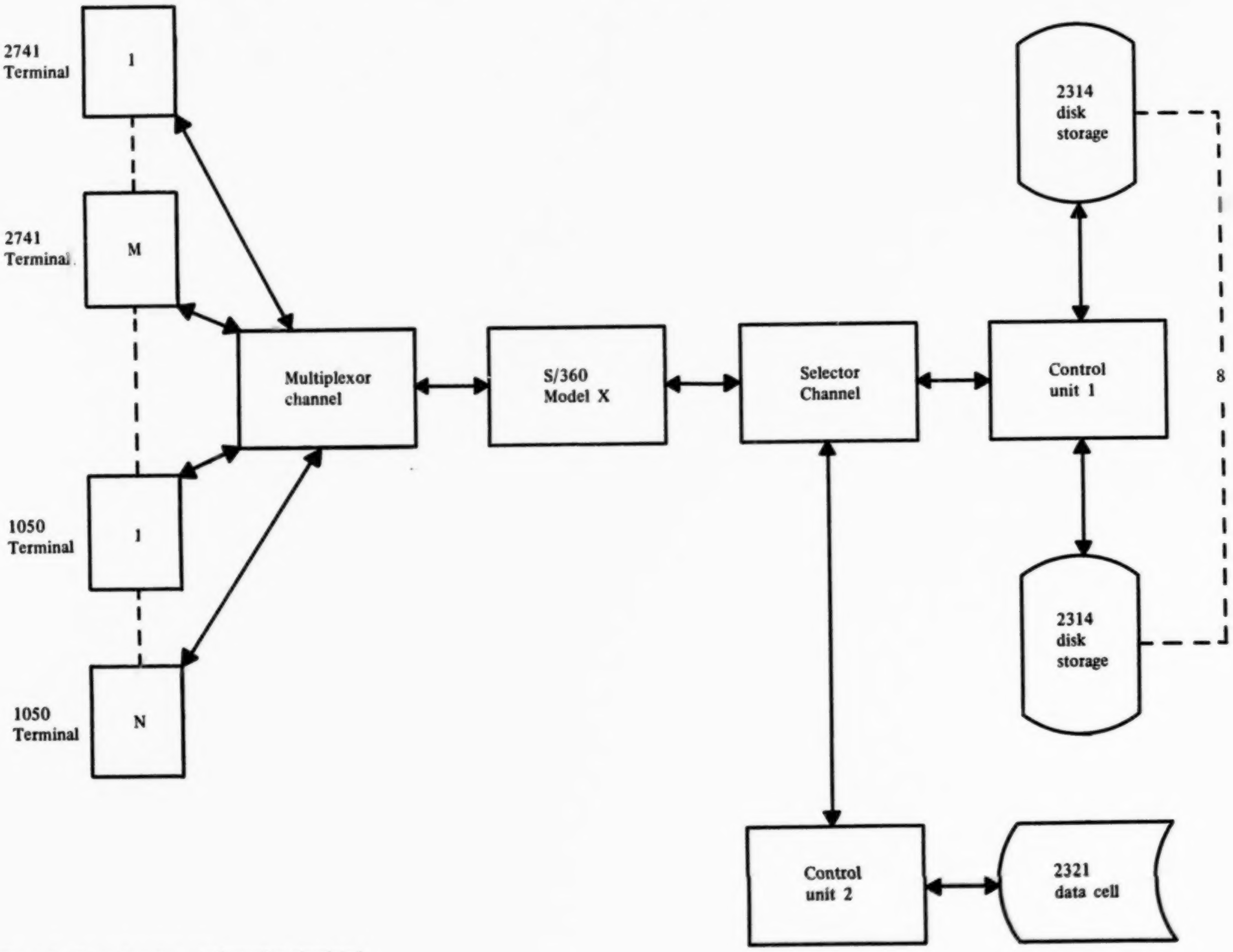

2741 Terminal
1
2741 Terminal
M
1050 Terminal
1
1050 Terminal
N
Multiplexor channel
S/360 Model X
Selector Channel
Control unit 1
2314 disk storage
8
2314 disk storage
Control unit 2
2321 data cell

Figure 8. General system configuration simulated

Input Parameter Development

Problem Solving. The study team conducted tests at an IBM 2741 terminal using typical secondary school instructional materials and a problem-solving language called APL*. In addition, secondary school officials were contacted where these terminals have been in use. It was determined that for each student request the average turnaround time is 60 seconds, the average CPU calculation time required is .25 seconds, and the average message lengths transmitted in and out are 17.5 and 8.75 characters, respectively. These parameters were used to modify the corresponding distributions measured on the APL/360 system at IBM Research. The distribution of message types, calculation versus various types of library operations, was unchanged (see Appendix F). Finally, the workspace size was reduced from 36,000 to 18,000 bytes.

Administrative Inquiries. The student accounting applications incorporated into the simulation model were attendance, guidance, and registration. Each of these areas was then subdivided to model the daily functions performed at each school. Attendance includes reporting absent students, tardy and early dismissal students, updating student records with reasons for absence (after the student has returned to school), and inquiries relative to unauthorized absences ("cuts") from class periods. Guidance inquiries enable the user to request a student's history to be displayed before counseling, and to subsequently update the record. The final area, registration, encompasses enrolling new students and adding their records to the student file, recording students transferring from the school, and updating student and course records as program changes occur. The number of each type of job was determined on a percentage-of-enrollment basis. The percentages were fixed after consultations with school officials.

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*APL (a programming language) was developed by Dr. Kenneth Iverson, IBM Research. The language is currently undergoing research implementation at IBM Research Laboratories, Yorktown Heights, New York.

By using a percentage approach, school districts of different sizes were accurately modeled. These statistics are provided in Table 12.

Average inter origination times for each of these inquiries are shown in Appendix F. To simulate the random generation of these inquiries, average inter-origination time was modified by an exponential distribution.

Results

Simulation results are sensitive to statistical variation as well as the logic of the simulation model and timing assumptions made by the user. Judgment must be exercised in determining the accuracy of the results. However, since major portions of the model were duplicated from an existing system, it is the opinion of the study team that the simulation results closely approximate the results which would be obtained from a live system developed from the simulated model.

All simulation runs were made with peak remote problem-solving workloads. The total real time simulated, that is, the time that represents "live" time units, such as a school period or a school day, was a function of the model region simulated and the time at which the established arithmetic means (response time and CPU time per problem-solving statement) became stabilized.

There are many results provided by the Computer System Simulator Program. Those results which are of major importance to systems design are response times and computer resource utilization.

Table 13 portrays the average response time for remote problem solving per statement entered and the remote administrative task response time per action input. These results are based upon the task priorities, with problem solving assigned the highest priority. A different priority sequence would produce different results for response time.

The performance objectives for the remote inquiry tasks are established with an average of 2.0 minutes response for the highest-priority administrative task, with the lower-priority messages queued for subsequent processing. Table 13 shows that this objective was met for all model regions except region C. In this case, it is felt that the desired administrative response time could be obtained by periodically assigning a higher priority to these tasks. If this were done, the problem-solving response time would change from

Table 12

PERCENTAGE OF ENROLLMENT PER DAILY
ADMINISTRATIVE JOB

Attendance	
*Absences	10%
Absence Reason Update	7.5%
Unauthorized Absence Inquiry	2.5%
Tardy-Early Dismissal	1.0%
Guidance	
**Student History Request	1.0%
Registration	
New Registrations	.2%
Transferring Students	.2%
Program Changes	2.0%

---

*All these entries will be made during the first period of the school day.

**A higher daily peak percentage of guidance requests is anticipated. However, it is expected that the remainder will occur before or after the instructional terminals are online.

its observed 2.2 seconds to some value closer to the 3.0 second objective. Time did not permit the simulation of this modification.

Table 14 contains utilization statistics, represented by percentage of time that the equipment components at the central site are utilized during the periods simulated. The equipment components presented are the CPU, high-speed direct access storage, and low/medium-speed direct access storage. No component at the central site achieves a 100% utilization during the peak remote problem-solving and administrative task period.

Appendix F contains samples of some of the more significant simulator output obtained for the USOE model region. These include response times and equipment utilizations.

Table 13

AVERAGE RESPONSE TIME OBSERVED IN SIMULATION

(All time in seconds)

Model Region	Priority							
	1	2			3	4		
	Prob. Solv.	Attendance			Guid.	Registration		
		Abs.	Cuts	Tdy.		Regis.	Trans.	Prog.
A	3.0	38	34	36	50	138	68	85
B	0.7	13	11	15	24	38	35	28
C	2.2	1407	1436	1502	Q	Q	Q	Q
USOE	1.0	87	98	97	1686	Q	Q	Q
CASE STUDY	1.0	22	20	20	88	156	67	113

Q: Message was transmitted from the administrative terminal and queued on administrative input queue within the central computing system, for processing after peak problem-solving periods.

Table 14

MAJOR EQUIPMENT UTILIZATION STATISTICS

(in percent utilized)

Model Region	Device									
	CPU	Low/Medium-Speed Direct Access Storage	High-Speed Direct Access Module*							
			1	2	3	4	5	6	7	8
A	72	31	19	19	23	21	-	-	-	-
B	65	38	2	11	10	11	11	6	6	6
C	93	19	3	20	22	16	22	3	5	3
USOE	80	46	2	10	10	11	10	6	7	8
CASE STUDY	67	47	2	18	18	18	17	6	7	7

*Use of High-Speed Direct Access Modules

Modules	All Regions Except A and USOE	USOE - Region A
1	Problem Solving Library	Problem Solving Library and Swap Area
2	Problem Solving Swap Areas	Programming System Residence and Swap Area
3	Problem Solving Swap Areas	Administrative Message Queue and Swap Area
4	Problem Solving Swap Areas	-
5	Problem Solving Swap Areas	Administrative Indices and Swap Area
6	Programming Systems Residence	-
7	Administrative Message Queue	-
8	Administrative Indices	-

PART 5: SYSTEM COSTS

This section contains estimates of the annual operating cost for the remote terminal computing system that satisfies the system specifications described in Volume II.

Annual operating cost estimates were developed for four model educational regions as described in Table 15. The estimates are preliminary, since they are based upon hypothetical model regions, initial estimates of workload, and apply only to the system designs presented. Final cost estimates can be established only after a specific design has been selected for implementation at a designated location. Although the cost estimates are preliminary, the basic system design has been shown to be technically and economically feasible for the stated environment. A summary of the cost data is presented in Table 16; detail cost data is presented in Appendix D. The data processing and communication equipment selections for each model region are presented in Table 17.

Costs for development and pilot installation of a remote terminal computing system are not included. These costs are quite variable and dependent upon many factors; further, a development and implementation plan is beyond the scope of this study.

ASSUMPTIONS

Assumptions used for developing the gross annual operating cost estimates listed in Table 16 and 17 are as follows:

1. Annual costs for the equipment are projected on a rental basis, which includes installation, maintenance, and programming systems support. Equipment rental figures were based on present IBM rental fees. No education allowance was assumed.

2. Costs for the central site data processing equipment, including the data communications control, are computed for a 300-hour per month usage for nine months per year for model regions A and B. Model C and the USOE model assume a 400-hour per month usage. The remaining three months for all regions are computed for normal prime shift usage of 176 hours per month. Monthly usage over 176 hours was computed at the current IBM rate, which is 10% of prime shift costs for extra shift use of standard computing equipment; there are no added extra shift charges for terminals and line adapters.

3. Common carrier costs for communications support are based upon representative interstate tariffs for full-time leased facilities. Established interstate tariffs were not used in this study as these are variable by state. The interstate tariffs used are presented in Table 18.

4. For costing the common carrier facilities, all terminals were assumed to be 25 miles away from the central computer. For data transmission to a school with a single terminal, the communication facility was assumed to be a standard 150-bit-per-second leased line, with appropriate common carrier communications termination. Where more than one terminal was planned for a school, a voice-grade transmission line was assumed with appropriate termination. In this case, a shared-line adapter is required from the DP manufacturer for multiplexing and coupling the terminal signals to a single voice-grade line. For selecting common carrier service, "terminal" applies to either an instructional or an administrative terminal.

5. Cost estimates for planning, facilities acquisition, site preparation, and other one-time charges are not included, since they depend on specific implementation programs. Also, normal overhead items, such as power, light, and air conditioning, and general and administrative expense, are not included, since they depend upon local circumstances.

6. Personnel needs listed in Table 19 are estimated for normal operations after startup. Only a minimum number of computer programmers have been included for special program development, since it is assumed that such special programs would be available from a central library of programs. No overhead was applied to the personnel salaries, since this is variable from district to district.

7. Supplies costs include expenses for comsumable supply items as well as the annual rental costs for the central site unit record card equipment, consisting of punches, verifier, reproducing machines, and interpreting machines. All data processing equipment is assumed to be commercially available as standard products with standard features. No equipment development costs are included in the estimates.

8. Computer/programming systems are assumed to be available and maintained according to the normal commercial practice. No programming systems development costs are included in the estimates.

COST ESTIMATES

The total gross annual cost for the total computing system was estimated for each model region. This total computer system cost includes the costs for the data processing equipment, common carrier equipment, personnel salaries, and supplies.

Table 15

MODEL REGIONS

Item	A		B		C		USOE	
Students per Secondary School	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled
500	2	1,000	3	1,500	5	2,500	-	-
1,000	5	5,000	10	10,000	15	15,000	-	-
1,500	6	9,000	14	21,000	20	30,000	-	-
2,000	10	20,000	20	40,000	30	60,000	50	100,000
2,500	2	5,000	3	7,500	5	12,500	-	-
Total enrolled 9-12	25	40,000	50	80,000	75	120,000	50	100,000
Total enrolled K-8	-	120,000	-	240,000		360,000	-	300,000
Total enrolled K-12	-	160,000	-	320,000		480,000	-	400,000
Total enrolled Jr. College (2,000 students per college)	1	2,000	2	4,000	3	6,000	2	4,000
Grand Total	26	162,000	52	324,000	78	486,000	52	404,000
District Admin. Centers	1	-	2	-	3	-	2	-

Table 16

SUMMARY ANNUAL COST ESTIMATES FOR SYSTEM

(in thousands of dollars)

	Model Regions			
Item	A	B	C	USOE
Central Computer Site	372.3	502.1	718.7	692.7
Remote Location	224.6	448.5	673.3	499.9
Equipment Total	596.9	950.6	1,392.0	1,193.6
Personnel	175.0	222.0	245.0	228.0
Supplies & Unit Record	20.0	30.0	40.0	35.0
Total	791.9	1,202.6	1,677.0	1,455.6
Total Region Operating Expense	86,184.0	172,368.0	258,552.0	214,928.0
% RTCCS Costs of Operating Expense	.86%	.70%	.65%	.68%
Administrative Costs Assigned	307.0	614.0	921.0	688.1
Instructional Costs Assigned	484.9	588.6	756.0	767.5

Table 17

EQUIPMENT SELECTION

	Model Regions			
Item	A	B	C	USOE
Central Site:				
--CPU Main Storage (characters)	256,000	256,000	512,000	512,000
--Direct Access Storage (characters)				
• High-speed	115,000,000	230,000,000	230,000,000	230,000,000
• Low/medium speed	400,000,000	400,000,000	400,000,000	400,000,000
--Sequential Storage (No. of magnetic tape units)	2	2	2	2
--Card Input/Output (No. of card read/punch units) (Cards per minute)	1 read 1,000 punch 300	1 read 1,000 punch 300	1 read 1,000 punch 300	1 read 1,000 punch 300
--Printer (No. and speed in lines/min.)	1 @ 600	1 @ 1,100	2 @ 1,100	2 @ 1,100
--Optical mark reader	2	3	4	4
--Communication control unit (No. of control lines)				
• Local Monitor terminal	1	1	1	1
• Secondary Schools	80	160	240	200
• Junior Colleges	3	6	9	6
• Administrative Center	4	8	12	8
Total	88	175	262	215
--Communication Terminations				
• Common Carrier	4	6	10	0
• DP Mfg. Adapter	83	169	252	215
--Average monthly usage (hours)				
• Summer (3 months)	176 hrs.	176 hrs.	176 hrs.	176 hrs.
• School year (9 months)	300 hrs.	300 hrs.	400 hrs.	400 hrs.
Secondary School:				
--Number of Schools	25	50	75	50
--Instructional Terminals	55	110	165	150
--Administration Terminals	25	50	75	50
Total	80	160	240	200

Table 17 (cont.)

Item	Model Regions A	B	C	USOE
--Communication Network				
• Single Comm. Lines	4	6	10	0
• Shared Comm. Lines	23	47	70	50
Total	27	53	80	50
--Communication Terminal				
• Common Carrier	4	6	10	0
• . DP Mfg.	76	154	230	200
Junior College:				
--Number of Schools	1	2	3	2
--Instructional Terminals	3	6	9	6
--Comm. Network				
• Shared Comm. Lines	1	2	3	2
--Comm. Terminal				
• DP mfg. adapter	3	6	9	6
Administrative Center:				
--Number of centers	1	2	3	2
--Printer/Keyboard Terminals	4	8	12	8
--Comm. Network				
• Shared Comm. Lines	1	2	3	2
--Comm. Terminal				
• DP mfg. adapter	4	8	12	8

Table 18

COMMON CARRIER INTERSTATE CHARGES

Item		Monthly Charge
150 bps Leased Line		
• Channel Termination	Central Site	$31.25
• Channel Termination	Terminal Site	$31.25
• Station Arrangement	Central Site	$25.00
• Station Arrangement	Terminal	$25.00
• Line Costs 1 - 100 miles @ 1.75/mile		$ 1.75/mile
Voice-Grade Line (One to four shared subchannels for use with DP manufacturer-supplied line adapters.)		
• First Channel		
Service Terminal	Central Site	$12.50
Service Terminal	Terminal Site	$12.50
• Each Additional Channel		
Service Terminal	Central Site	$ 7.50
Service Terminal	Terminal Site	$ 7.50
• Line Costs		
1 - 25 miles		$ 3.00/mile
26 - 100 miles		$ 2.10/mile

Table 19

ANNUAL COSTS FOR PERSONNEL AND SUPPLIES

Item	Model Regions							
	A		B		C		USOE	
	No.	Total Salary($)	No.	Total Salary($)	No.	Total Salary($)	No.	Total Salary($)
Director	1	16,000	1	18,000	1	20,000	1	18,000
Secretary	1	6,000	1	6,000	1	6,000	1	6,000
School Coordinator	1	15,000	2	30,000	3	45,000	2	30,000
System Manager	1	14,000	1	16,000	1	16,000	1	16,000
Operation Manager	1	12,000	1	14,000	1	14,000	1	14,000
System Analyst	2	24,000	2	24,000	2	24,000	2	24,000
Programmer	2	20,000	3	30,000	3	30,000	3	30,000
Programmer Trainee	2	14,000	2	14,000	2	14,000	2	14,000
Operator	5	30,000	6	36,000	7	42,000	7	42,000
Keypunch Operator	3	15,000	4	20,000	4	20,000	4	20,000
Clerk	1	4,000	1	4,000	1	4,000	1	4,000
Courier	1	5,000	2	10,000	2	10,000	2	10,000
Total Salary ($)		175,000		223,000		245,000		228,000
Supplies and Unit Record		20,000		30,000		40,000		35,000
Total Expense ($)		195,000		252,000		285,000		263,000

A school budget was computed for each region on the basis of an annual operating expense of $532 per student in grades K-12 (for 1965-66, as described in the USOE Digest of Education Statistics). Since an annual cost for junior college students could not be obtained, the $532 figure was also used for this population. The ratio of total computing system costs to the total budget is expressed as a percentage shown in Table 14.

To distribute costs for instructional use at the secondary school and junior colleges, the estimated value of administrative data processing services was first computed. The value for administrative data processing services was based on the experience of typical school systems around the nation, and is listed below:

Secondary Students. The pupil personnel services are valued at $4.00 per student per year. In addition, the business administrative services for these students are valued at $1.50 per student per year.

Elementary Students. The value for business administrative services is established at $0.50 per student per year. In addition, 37.5% of the elementary student population receive extensive services for processing of tests, which is valued at $0.60 per student per year.

Since junior college administrative data processing is not performed by the system, no administrative values are placed on this student population.

On the basis of the assigned values, the total administrative value of the system was computed, and subtracted from the gross annual costs to leave the net annual system costs for instruction.

The net annual instructional cost was distributed to secondary school and junior colleges on the basis of their percentage of total workload. The cost per student was determined from school enrollment and junior college enrollment for each model. The cost per student was further distributed by costs for problem solving and data processing training. For this latter distribution, it was assumed that data processing training problem sessions utilize four times the computing service as compared with the utilization for problem solving. These costs are valid only for the workload criteria established for each model region, and should not be used without reference to this workload.

BILLING SYSTEM

All users receiving services from the central computing site should be charged for services on a basis that will make the center financially self-sufficient, either from district funding, or through a combination of district funds and external funding sources. While many methods may be used for computing these charges, the method selected for implementation must be compatible with the school budgetary system, and any requirements to qualify for any external funding sources.

Three approaches to billing were considered, one based upon distance from the central site and actual utilization of the computing system; the second, based upon a fixed charge to the schools; and a third, based upon a combination of the first two.

A charge based upon actual utilization alone was found to be inappropriate. Since school annual budgets are prepared in advance of the school year, establishing projected charges for precise utilization may lead to substantial budgetary differences. Furthermore, utilization charges can lead to restricted uses of the system by the teacher and the student. The teacher who wants to provide more classroom demonstration uses of the system should not be penalized. An advanced student who may process more problems, or problems of greater complexity, should not be restricted from access to the system. Furthermore, the geographic distance of a school from the central site should not discriminate against user system access.

The remote terminal computing system is engaged with one commodity, educational services. Many standard elements are inherent within the total system: students, teachers, administrators, and tasks to be performed. The total system workload is predicated upon one major factor; that is, the size of the user population.

It is recommended that when only district funds are available to support the center. the annual cost to a school be based upon student population with fixed charges per student. This method for projecting costs provides the school administrators with more accurate data for budget purposes. The student and teacher are provided system access without restraints due to financial considerations.

The recommended method for assigning charges to a user is as follows:

Total Operational Costs. Each user provides the central computer management with the actual enrollment on a set date in the current school term. The total operational costs for the next year of operation are established for the central site. In addition, the cost for all remote terminal equipment and communication costs are established. A total annual operations cost figure is computed for the center, including remote equipment and line charges. These are then prorated on the basis of current enrollment.

Administrative Services. The assigned administrative service value per elementary and secondary student receiving services is used to compute administrative costs for the budget year, using the current enrollment. The total administrative services costs are deducted from the total computer services operational budget. The remainder represents a cost to be used for instructional services.

Instructional Services. Costs for instructional services are comprised of costs for problem solving and data processing training. A per-pupil service value is assigned for all courses within the data processing training curriculum, excluding a computer concepts course. The per-pupil value is extended by the number of students to be enrolled in the data processing course. This total value is deducted from the costs for instructional services. The remainder now represents the value assigned to problem solving. The problem-solving value is divided by the total number of terminals to be used in the system during the next year to produce the cost per terminal. The cost per terminal is the basis for problem-solving service charges to the school, and is extended by the number of terminals to be installed at the school site.

Combination Method. Where external funding is available, reimbursement may be based upon usage by individual students. For example, assistance might be based upon a formula that provides a reimbursement for each hour of student use, up to a maximum set value for any one student. Through this technique, assurance is provided to the external funding agency that availability of the system is extended to the greatest number of students, and that no small group of students is permitted the full use of the system, to the exclusion of others. Since the claim for such funds would be based upon actual usage before reimbursement, the billing method would be fixed in advance for district contributions, but based upon statistics gathered as part of the accounting routines for claiming of assistance funds.

It must be understood that the above system is designed to allocate operational costs. Fixed costs of the computer center site and buildings must be initially provided on a different basis, as must be the development costs of the system incurred before the start of actual operations.

APPENDIX A: ANALYSIS OF CONVERSATIONAL VS BATCH PROCESSING FOR PROBLEM SOLVING

The conversational system used for the comparison was configured with a single medium-speed processor using 200 remote terminals in the schools. Of these, 50 contained card read/punch and keyboard/hard-copy capabilities; 150 contained only the keyboard/hard-copy capability.

The remote batch system was configured with two high-speed processors to perform the workload and meet the same throughput requirements. For this system, 100 remote terminals were configured with card read/punch and keyboard/hard-copy capabilities. In addition, 50 keypunches were included.

The annual total cost of data processing equipment and communication facilities for the remote batch entry system is 89% greater than that for the conversational system, when supporting the workload projected for the USOE model region. The lower costs for fewer terminals in the remote batch system are offset by the fact that the card read/punch terminal is more expensive than the conversational terminal. Total costs for communication equipment for the remote batch system are considerably less than the conversational system because fewer terminals are used. However, these costs are offset by the central processor costs, which are substantially higher for the remote batch system because of the increased number of jobs to be processed.

Table 20 presents a summary analysis of the comparison. The key advantage of the conversational mode for student jobs is the ability to process many small jobs concurrently.

Table 20

COMPARATIVE ANALYSIS OF CONVERSATIONAL VS REMOTE ENTRY BATCH MODES

Task	Conversational Method	Remote-Batch Method
1. State the problem in machine-readable form	Typed directly into system	Prepared offline on cards
2. Correct errors in the problem statement (debugging)	Syntax errors addressed line-by-line. Logic errors addressed at any execution point. Immediate correction possible.	Errors addressed after compilation and attempted execution. Correction possible before subsequent compilation.
3. Execute the problem	Direct execution of the problem by interpretation process	Delayed execution of the problem by compilation process
4. Receive the results	Immediately received at terminal	Delayed, as 3 above
5. Change data for subsequent executive runs	Immediate changes made at the terminal	Changes prepared offline
6. Receive results of subsequent execution runs	Immediately received at terminal	Delayed, as 3 above
7. Save programs	System saves defined program at user's request	System saves defined programs at user's request
8. Store data	Data files stored	Data files stored
9. Annual cost (data processing and communications equipment only) for USOE model region	$1,176,918	$2,230,144

APPENDIX B: DATA PROCESSING TRAINING COURSE OUTLINES

(Note: Topic outlines for the data processing training course outlines contained in this appendix are based on portions of a curriculum for the Ontario Department of Education, Toronto, Canada.)

Computer Concepts

Length: Two terms, 150 hours (one class hour per day)
Grade: 10, 11, 12, 13, 14
Prerequisite: None

This basic course is a comprehensive appreciation of data processing concepts. Although the student is expected to master some topics in considerable detail, a general understanding of data processing and the ability to write simple programs should be the major objectives.

1. Manual data processing methods
   a. Early manual and mechanical techniques
   b. Early coding techniques
   c. Flowcharting
   d. Applications of coding
   e. Output
2. Evolution of the electric computer
   a. Advanced technology in modern society
   b. Electromechanical equipment
   c. The electronic computer
3. Physical characteristics of the computer
   a. Central processor
   b. Input/output devices
4. Programming the computer
   a. Need for, and functions of, a programmer
   b. Programming concepts
5. Role of the computer in today's society
   a. Uses, advantages, limitations
   b. Development of programming languages
   c. The future of data processing
   d. Vocational opportunities in data processing
6. Problem types
   a. Basic arithmetic
   b. Looping and counting
   c. Comparing and branching
   d. Basic input/output

Introductory Programming

Length: Two terms, 150 hours (one class hour per day)
Grade: 11, 12, 13, 14
Prerequisite: Computer Concepts

The object of this course is to teach programming fundamentals. Enough of one computer language (FORTRAN, COBOL, or another higher-level language or machine language) should be presented to give the student familiarity with that language and to allow him to write and test problem programs.

1. Introduction
   a. Review computer concepts
2. Programming
   The following topics should be covered in the language chosen:
   a. Basic input/output
   b. Data movement
   c. Comparing and branching
   d. Basic arithmetic
   e. Advanced arithmetic
   f. Data formatting
   g. Reading serial records
   h. Looping and counting
   i. Address modification
   j. File formats
   k. Subroutines
3. Program testing techniques
   The following topics should be covered:
   a. Disk checking
   b. Error messages on compiling
   c. Test data preparation
   d. Control cards for testing system
   e. Test runs
   f. Correction and rerun
4. Documentation
5. Problem types
   a. Basic arithmetic
   b. Looping and counting
   c. Comparing and branching
   d. Address modification
   e. Basic input/output

Systems Design

Length: Two terms, 150 hours (one class hour per day)
Grade: 12, 14
Prerequisite: Computer Concepts, Basic Programming

Upon satisfactory completion of this course, the student should be able to design a computer system for given input/output and procedure specifications and be able to document the design. The student will choose a case study within his experience to introduce and illustrate design concepts. He will develop the design of a system from the case study for application, using sequential and direct access processing.

1. Systems design for sequential access (tape system)
    - a. Output of system
    - b. Input to system
    - c. Processing required to produce output from input
    - d. Controls
    - e. Form design
    - f. File consolidation
    - g. Division of processing into runs
    - h. Master record designs
2. Systems design using direct access (disk system)
    - a. Implementation of direct access system, using general system design defined in 1, above
3. System investigation
    - a. Information and documents to be gathered
    - b. Information-gathering methods
    - c. Documentation results
4. System analysis
    - a. Objectives of analysis to pinpoint problem areas, improve operations, and decrease costs
    - b. Documentation of results of system analysis
5. Case study
    - a. Student will design and test a system using a simulation program. The simulation would require four processing runs on a computer.

Business Systems Programming

Length:	Two terms, 150 hours (one class hour per day)
Grade:	12,14
Prerequisite:	Computer Concepts, Basic Programming

Upon completion of the course, the student has an understanding of file processing, data processing, and data handling in a business environment.

1. Programming
    - a. Review of basic programming
    - b. Language features used to read and write serial files
    - c. Language features used to read and write direct access files
2. File processing techniques
    - a. General concepts
    - b. Batch processing
    - c. Immediate
3. Sorting methods
    - a. Methods used on tape computers
    - b. Methods used on computers with direct access devices
    - c. Timing considerations of sorting
4. Input data editing and validating
    - a. Completeness checks
    - b. Validity of individual records
5. Overall system control
    - a. Use of control sheets
    - b. Audit trails
    - c. Rerun and error correction procedures
    - d. Emergency procedures
6. Report preparation
7. Monitors
8. Case study
    - a. Design, flowchart, code, test, and document a business system, including:
        - File maintenance program
        - Report program

Unit Record Fundamentals

Length:	Two terms, 150 hours (one class hour per day)
Grade:	12,14
Prerequisite:	Computer Concepts

Some schools may wish to continue teaching the principles of unit record punched-card data processing, especially in those areas where employment may depend on a unit record background.

1. Functions

    Machine functions and operating features for each of the following:
    - a. Keypunch
    - b. Sorter
    - c. Reproducing punch
    - d. Interpreter
    - e. Collator
    - f. Accounting machine
    - g. Selection
    - h. Storage
2. Functional wiring principles
    - a. Card reading by machines
    - b. Control panels
    - c. Printing
    - d. Comparing
    - e. Punching
    - f. Column splits
    - g. Selection
    - h. Storage
3. Programming
    - a. Accounting machine
    - b. Collator
    - c. Calculator
4. Procedure development
    - a. Flowcharting
    - b. Three basic steps in procedures

    c. Preparation of reporting requirements
    d. Development of card design
5. Report Generation
    a. Introduction
    b. Input/output
    c. Arithmetic
    d. Condition codes
    e. Advanced input/output
    f. Case studies and review problems

APPENDIX C: ADMINISTRATIVE FILE DESCRIPTIONS

Many of the files have specific data elements shown, and an approximation as to the number of characters that might be expected in each element. The student file is especially detailed because of its importance. Most of the data elements shown in the student file, however, are optional; no actual case of all of them. As a result, the total file size for workload analysis purposes has been based on an estimated average size, rather than a maximum size.

System Model: Student
File Name: Student
Character of Data:

All information on each student currently enrolled, or who has been enrolled at any time during the school year but has not yet actually enrolled. The actual record for any student would be comprised only of data supplied through registration or update procedures, or through by-products of other tasks, such as scheduling, grade reporting, attendance and test scoring, etc.

Maximum Size Record

1. Indices to Data in Student Record
   24 Eight entries of three positions each for the information types
   150 Fifty entries of three positions each for the field types
2. Data Identification Codes within Field Types
   284 Data element codes of one position
3. Positions Required at Maximum per Information Type
   187 Personal Information
   194 Family Information
   238 Health Information
   169 Enrollment Information
   1,646 Standardized Testing Information
   13,196 Academic Information
   745 Guidance Information
   758 Other Information
4. Total Positions Required in Defined Record at Maximum: 17,591

File Storage Requirements

In determining the amount of file storage required, the following assumptions have been made:

1. No historical data from elementary grades would be available.
2. No test data at startup except from new enrollees during year.
3. Test data scored during each year involves one battery, 1/3 of the total students.
4. Personal information relatively complete, but minimum family data.
5. No health information available at startup.
6. Minimum enrollment information.
7. No course requests for next year; current year requests at minimum.
8. Almost no guidance information at startup.
9. None of the other information during the first year.

Based on the above, the estimate of file storage allocation per student during the first year is 2000 positions.

File overflow provisions include one full track in cell-type memory per student. Track contains address of overflow trailer track. If trailer track overflows, another address is given. There is room for 10% overflows per storage card in cell.

System Model: Student
File Name: Demographic
Character of Data:

1. Census tract populations (age, ethnic)
2. Health district births (ethnic)
3. School zone enrollments (grade, ethnic)
4. Housing starts (type and time)
5. Housing removals
6. School capacities and program facilities
7. Parochial and private enrollments
8. Possible annual pupil address survey (ethnic)
9. Possible real estate data from property data bank (value, number of households)

All of the above data is stored with geographic coordinate tags to permit aggregation to any desired level ("community", intermediate-school planning area, etc.).

The data in this file is designed to:

1. Deal individually with small areas, ethnic groups, etc.
2. Use regression analysis instead of merely extrapolating past averages where such curve-fitting is warranted.
3. Update migration models (i.e., verify assumptions about housing preferences of various household types).
4. Use recent ethnic birth data as a sensitive current indicator of migration trends.
5. Use ratio method (on a large scale) to adjust cohort-survival estimates.
6. Make systematic and explicit use of parochial (and other private school) enrollment data and forecasts.

7. Provide long-range projections to guide the planner; use the data to produce curves of school-age population vs time in new housing developments. The results of applying these procedures are estimates of the distribution of school-age children by grade, by ethnic group, by small area (e.g. attendance zone), by year.

System Model: Student
File Name: Census
Character of Data:

Information on each residence within the district boundaries served. Information on each family residing at the address and each child of school age or younger. Much of the information collected on a student at the time he registers can originate from this file, and many of the updates to the student file can also update this file at the same time. Much of the personal and family information data in the Student file is also common to this file. This file is used in conjunction with the Demographic file to produce enrollment estimates, and other projections of school building requirements.

System Model: Staff
File Name: Applicants
Character of Data:

Information to identify each applicant and his qualifications for the job or position. Evaluations resulting from interviews, or contacts with prior employers, special qualifications, etc. Special preferences for specific assignments when multiple openings for a job may exist.

File Name: Substitutes
Character of Data:

Information similar to that contained in the Applicants file, plus information on the prior assignments within the district and evaluations of the work performed during such periods.

File Name: Employee
Character of Data:

Full information identifying each employee, permanent, temporary, substitute, terminated, etc., for a defined span of time after last employment. All information necessary for payroll and income tax (dependents, etc.). A history of employment before the current employment period, plus a record of each assignment internally, pay rates, etc. A history of all educational qualifications or experience to determine salary placement is included where applicable.

System Model: Fiscal
File Name: Payroll
Character of Data:

This file may be part of the Employee file in the Staff system model, or may be separately organized for internal accounting control. It contains information as to pay rates for each job classification in which employees are authorized to work, totals for each category of gross salary, and involuntary deductions. Each authorized voluntary deduction is detailed, plus totals remitted for same during the current accounting period.

File Name: Budget/General Ledger
Character of Data:

This file contains a record for each active account code during the current year, or planned for the coming year. It contains summary figures for the original budget allocation, currently adjusted budget, and current ledger balance and encumbrance totals. It contains information on any allocation formulas for redistributing costs that are predefined to be distributed on a formula basis. It contains detail transactions that have been entered during the current and the past accounting period. Since detail listings are produced for each period, earlier transactions are eliminated from this source, but saved for use at the end of the year.

File Name: Vendor
Character of Data:

This file contains a record for each active vendor for the past three years. It contains information as to the last several transactions, total volume of business done with this vendor, and the types of items supplied by this vendor.

File Name: Purchases
Character of Data:

This file contains a record for each purchase order issued during the current year, or any issued in anticipation of the start of the coming year. It contains as much detail as is available, which may be full detail or summary data. It is updated upon receipt of the item ordered, with the date received, and actual price charged when the invoice arrives.

File Name: Warrants Issued
Character of Data:

This file contains a record for each warrant issued, and detail as to the items or invoices being paid. The file contains data only for the current year, and a new file is started with the start of a new year. Full identification of the vendor or payee is included, with all amounts, discounts, taxes, etc.

File Name: Budget Appropriations
Character of Data:

This contains the data on the originally adopted budget in full detail as approved or originally accumulated. It contains detail as to each adjustment of the budget approved after that point.

File Name: Maintenance Jobs
Character of Data:

This file contains a record for each job, either specifically written for a special purpose, or a general or annual type job used for the normal type of day-to-day maintenance, etc. Information as to the budgeted or expended man-hours, and costs of labor to date, plus costs of materials expended is included.

File Name: Construction Projects
Character of Data:

This file identifies each construction project under way. It identifies each contractor, or subcontractor, with information on amounts authorized or actually paid, and the nature of the work performed. To the extent possible, this file also contains the information necessary to perform critical path analysis of the schedule of the work under way.

System Model: Property
File Name: Equipment
Character of Data:

This file contains a record for each separately identified piece of equipment, as identified by a serial-numbered property tag; in addition, certain property not tagged, but inventoried. Records of the manner in which the property was obtained or purchased, cost, expected life span, and, of course, full identification by description, serial numbers, manufacturer, size, etc., are included.

File Name: Facilities
Character of Data:

This file contains a record of each location of fixed facilities. From this file it is possible to determine (a) the number of square feet of different types of facilities, or (b) the use of facilities. It contains records of the improvements included, descriptions of the facilities, etc.

File Name: Library
Character of Data:

Each book, periodical, phamphlet, etc., is separately cataloged. Obviously, considerable time is required to reach this level of automation. Initially, new books may be the only data in this file, and the business aspects of ordering books provide this data as a by-product. Under a planned program of automation, each book will eventually be included.

File Name: Audio-Visual Materials
Character of Data:

Each filmstrip, map, etc., that is distributed on a circulating basis is included with a full description and a record of all dates scheduled, locations, etc.

File Name: Educational Supplies
Character of Data:

Each item stored in the warehouse, with vendor numbers of vendors interested in supplying, and their previous history of bidding, etc. The quantity on hand, on order, on back-order, etc., is included, with the history of the demand for the item during each review period. Eventually, items not in the warehouse will be included, on an almost identical basis, enabling the schools to order without regard to the source of the item to be supplied.

File Name: Maintenance Supplies
Character of Data:

Each item of maintenance material required by the job shop, trucks, job sites, etc. Since the unit of issue varies, quantity must be able to be issued in varying issue units, while maintaining control in the other unit of measurements. Substitute items can be referenced for referral in an out-of-stock condition.

File Name: Cafeteria Supplies
Character of Data:

Each item of perishable or nonperishable foodstuffs, or cafeteria supplies, such as silverware, etc., which is stored centrally, or stored locally in the school, or purchased directly. For items stored centrally, the usual demand history, and inventory quantities, on order, back-order, etc., must be contained. For items stored locally, the quantities received, and on-hand at inventory time, must be provided for, to enable computation of usage during each inventory period.

System Model: Curriculum
File Name: Course
Character of Data:

Each course offered in a school, or in the district at any location. Courses are identified by number and course title. Statistics as to the numbers enrolled by location can be maintained.

File Name: Classes
Character of Data:

A record for each class offered within each school is available. Information as to the course number being taught, or multiple courses if more than one is being taught concurrently, is contained, the room or rooms offered, the periods, days met, and semester of the schedule, and the instructor codes and names assigned. Numbers of students enrolled at all times are maintained; the identification numbers of the enrolled students may be included for preparation of class lists without sorting student class information from the student file.

File Name: Test Item Bank
Character of Data:

Each test item submitted by teachers throughout the area served, plus its taxonomy coding. The history of use of the item by school and date, and the analysis of responses within each school, and in total. This provides for computation of the discrimination index, and difficulty of the item, for automatic selection of test items by classification and use statistics.

File Name: Test Conversion Tables
Character of Data:

Publisher tables required to convert raw or intermediary scores to converted scores for presentation back to the schools.

File Name: Test Scoring Keys
Character of Data:

Correct responses for each standardized test to be scored.

File Name: CAI Units
Character of Data:

CAI Units in a course-writer language for instruction in data processing operation and programming techniques, or other curriculum areas in which CAI may be involved. Of interest for inclusion in this file are locally developed CAI units, or such units in the process of being developed and tested locally by staff members.

ADMINISTRATIVE FILE LAYOUTS

FILE NAME: STUDENT

SIZE DATA ELEMENTS

PERSONAL INFORMATION

Identification

8	Student Number -- assigned by computer upon registration.
10	Social Security No. and check digit assigned upon registration.
30	Student Name -- Last, First, Middle Initial, Name Suffix (Jr., etc.)
1	Sex
1	Eyecolor -- an additional identifier to locate a student by name.
1	Race
51	

Birth

6	Birthdate -- Month, Day, Year -- XX/XX/XX
25	Birthplace
2	Birthplace code -- defines distance from school location, etc.
1	Citizenship
34	

Status and Affiliations

1	Marital Status
1	Religious Affiliation
2	

Residence

5	Street Number -- integers only, or P.O. Box No., etc.
4	St. No. fraction, location, such as 1/2, 1/4, REAR, BOX, etc.
20	Street Name, or Post Office location if Box, etc.
4	Type of Street -- St., Ave., Blvd., Road, Lane, Crt., Plce., etc.
5	Compass Area -- North, East, South, West, N.E., N.W., etc.
4	Apartment, Floor, Lot No., etc.
20	City or Post Office if unincorporated, etc.
5	State
5	ZIP Code
72	

Other Data

10	Residence Phone -- may require area code in some localities.
20	Car Yr., Type, and Licence No. if any
30	

Total: 189

FILE NAME: STUDENT

SIZE DATA ELEMENTS

FAMILY INFORMATION

Father/Male Guardian

1	Relationship Code
25	Name -- Normal first-initial-last sequence, preceded by title such as Dr., Mr., etc.
1	Race
1	Educational Attainment Code
25	Employer's Name
15	Employer's Phone and extension, with area code if required
3	Occupation Code
71	

Mother/Female Guardian

1	Relationship Code
25	Name -- Title (Miss, Mrs., etc.), first-initial-last sequence
1	Race
1	Educational Attainment
25	Employer's Name
15	Employer's Phone and extension, with area code if required
3	Occupation Code
71	

Household

1	Number of older brothers in household
1	Number of older sisters in household
1	Number of younger brothers in household
1	Number of younger sisters in household
1	Number of other children in household
3	Languages (other than English) spoken in household -- multiple 1-dig.
1	Socio-economic level of household
9	

Dist. Revenue Qualifications

1	Tuition status
3	Federal Assistance Qualifications -- multiple 1-digit codes
4	

Emergency contact

25	Neighbor's name
10	Neighbor's phone
35	

Transportation

1	Transportation Eligibility
3	Bus Route or local carrier identification
4	

Total: 194

FILE NAME: STUDENT

SIZE DATA ELEMENTS

HEALTH INFORMATION

Medical Emergency

25	Physician's Name of student or family
10	Physician's phone -- may require area code
3	Health Plan Coverages -- multiple 1-digit codes
38	

Examinations

6	Date of last physical examination
1	Condition Code
6	Date of last dental examination
1	Condition Code
6	Date of last height/weight measurement
3	Height -- in total inches
3	Weight -- in total pounds
6	Date of last visual examination
1	Condition Code
3	Uncorrected vision -- left eye
3	Uncorrected vision -- right eye
3	Corrected vision -- left eye
3	Corrected vision -- right eye
6	Date of last hearing examination
1	Condition Code
2	Hearing loss -- left ear
2	Hearing loss -- right ear
56	

Impairments affecting schoolwork

1	Vision
1	Hearing
1	Speech
1	Allergies -- multiple 1-digit codes
1	Blood Dyscrasia, Hemophilia, etc.
1	Diabetes
1	Epilepsy
1	Glandular -- multiple 1-digit codes
1	Heart -- multiple 1-digit codes
1	Neurological - multiple 1-digit codes
1	Kidney
1	Orthopedic
1	Positive Tuberculin or chest X-ray
1	Mental Retardation
1	Emotional Disturbances
1	Cultural Deprivation
16	

Immunization Status

6	Small Pox -- Initial vaccination date
6	Small Pox -- Revaccination Date
6	Diphtheria -- Tetanus -- Initial vaccination date
6	Diphtheria -- Tetanus -- Booster vaccination date
6	Measles vaccination date
1	Poliomyelitis -- type of vaccine received
6	Poliomyelitis vaccination series completion
6	Tuberculin Test date
6	Survey Chest X-ray date
6	Full Chest X-ray date
55	

Physical Fitness Testing

6	Date Tested
1	Test Battery Identification
2	Year Published
2	Level and Form used
2	Norms used
1	Subtest identification
3	Raw score -- time, distance, counts, etc.
2	National percentile norm
2	Local percentile norm
40	Five additional subtests of eight positions each
61	

Total: 226

FILE NAME: STUDENT

SIZE DATA ELEMENTS

ENROLLMENT

Grade

2	Grade of current school year or semester
2	Grade to be used for summer school if enrolled
2	Grade expected to be in during next school year or semester
6	

Credits

3	Cumulative credits through last semester
3	

Grade Point Averages

3	Academic grade points cumulative through last semester
3	Total grade points cumulative through last semester
2	Number of units attempted (divisor for obtaining GPA)
8	

Grade Point Percentiles by Subject Areas

2	Weighted GP percentile for first Subject Area -- each grade received for credit is converted to a percentile, and averaged 50-50 with any prior GP percentile if any, or used directly if first in subject area
22	Eleven additional GP percentile subject areas of two positions each. Note: through this technique the most recent mark receives 50% of the total weight, the prior mark 25%, next prior 12.5%, etc.
24	

Rank in Class

4	Rank position in class based on cumulative total grade point average
4	Number rank
2	Rank Percentile -- provides a rank comparable between different size groups
10	

Next School

3	Summer School code if enrolled
3	School to attend next year or semester
6	

Enrollment Data

6	Date enrolled in this school
1	Enrollment type code
7	

Prior Education

3	Last school attended within district
15	Last school attended outside district
18	

Withdrawal

6	Date Withdrawn from this school
1	First Withdrawal reason given
1	Second Withdrawal reason given
3	Next School to attend within district
15	Next School to attend outside district
4	Follow-up actions if apparent dropout at this time
30	

District Funds Owed or Paid

1	1st Charge reason owed code
4	Amount owed
4	Date accrued
1	2nd Charge reason owed code
4	Amount owed
4	Date accrued
1	3rd Charge reason owed code
4	Amount owed
4	Date accrued
4	Total additional amount owed accrued this school year
4	Total additional amount owed accrued during past school years
1	Last amount paid reason owed code
4	Last amount collected
4	Last date paid
1	Previous amount paid reason owed code
4	Previous amount collected
4	Previous date paid
4	Total of all previous amounts (except above two) collected this year
57	

Note: Above include all book and course fees, library fines, etc.

Total: 169

STANDARDIZED TESTING INFORMATION

Standard Format used for all test data

Once per Battery -- 15 posns.

6	Date Tested
2	Publisher Code
3	Battery Code
2	Year Published
1	Form Code
1	Level Code
15	

Once per Subtest -- 17 posns.

2	Subtest Code
3	Raw Score
1	1st Norm Type Code
3	1st Derived Score
1	2nd Norm Type Code
3	2nd Derived Score
1	3rd Norm Type Code
3	3rd Derived Score
17	

TYPES OF TESTS: Positions based on given estimates of subparts. In use, only the actual number of subtest modules required would be actually included in the record.

Intelligence Tests

166 Two batteries, four subtests each battery

Achievement Tests

740 Four batteries, ten subtests each battery

Vocational/Interest Tests

370 Two batteries, ten subtests each battery

College Entrance Tests

370 Two batteries, ten subtests each battery

ACADEMIC INFORMATION

Current Information

Once per class in which enrolled currently -- 100 posns.

6	Course Code
4	Section Number of this class
3	Instructor Code
2	First period of this schedule component
1	No. of periods in consecutive block of this schedule component
5	Days met for this schedule component
1	Semester met for this schedule component
9	Second component of this schedule
9	Third component of this schedule
20	Course Title
20	Instructor Name
2	First mark received
2	Second mark received
2	Third Mark received
2	Final mark received
4	Other nongrade marks received, comments, work habits, citizenship, etc.
1	Conditions under which this course taken -- noncredit, repeat, etc.
2	Credits to receive if passed, or earned at end of semester
2	Grade points earned at end of semester
3	Days Absent since start of course, or date enrolled in course
1100	Eleven additional class positions in above format

Requests for next year or semester, and tentative schedule assigned

Once per course requested -- 91 posns.

6	Course number requested
1	Alternate status or preferred status
1	Specific semester or single semester of full-year course if any
4	Specific section requested if any
3	Instructor Code requested if any
1	Conditions under which course to be taken -- noncredit, repeat, etc.
4	Specific section scheduled
3	Instructor assigned to this section
9	First component of schedule for this section -- see format above
9	Second component of this schedule
9	Third component of this schedule
20	Course title
20	Instructor Name
1	Reason for rejection if could not be scheduled
1477	Seventeen additional requests in above format

Historical Information -- Reverse chronological sequence (latest first)

School Attended -- once per each new school attended -- 62 posns.

25	School Name
25	City/State of School
12	First and last data attended school -- blank in last if still enrld.

GRADES 7-12 ONLY

Semester Attended -- once for each new semester attended -- 18 posns.

2	Grade during the semester
1	Semester being reported
12	First and last date attended during this semester
3	Instructional days included in this semester

Class Attended -- once for each class in which enrolled -- 66 posns.

6	Course Code in which enrolled -- includes group if applicable
20	Course Title
20	Instructor Name
2	First mark received
2	Second mark received
2	Third mark received
2	Final mark received
4	Other nongrade marks received, comments, work habits, citizenship, etc.
1	Conditions under which this course taken -- noncredit, repeat, etc.
2	Credits received for this class
2	Grade points earned for this class
3	Days Absent during this class
660	Eleven additional class positions in above format
7458	Eleven additional semesters each with twelve classes
124	Two additional schools expected in maximum record

GRADES K-6 ONLY

248	School Attended -- See above format -- four schools provided for

Year Attended -- once for each year of school

2	Grade during the year
12	First and last date in school year

Course and Grades received -- one for each course taken

20	Course Title
2	Final Mark
220	Eleven additional courses per year
1536	Six additional years of elementary school

GUIDANCE INFORMATION

Assignments

4	Home Room or Advisory Room No.
3	Home Room or Advisory Instructor Code
20	Home Room or Advisory Instructor Name
3	Counselor Instructor Code
20	Counselor Name
50	

Lockers

5	Main Locker No.
6	Main Locker Combination Code
8	Student Number of Locker Partner
6	Main Locker Padlock Serial No. if not built in lock
5	Gym Locker No.
6	Gym Locker Combination Code
6	Gym Locker Padlock Serial No. if not built in lock
42	

Academic

1	Course of study, or track
1	Projected college and Major
1	Projected college and Minor
2	Ultimate educational objective
1	Post graduate plans
9	1st College to which application made
9	2nd College
9	3rd College
33	

Future Years Course Plans

6	A course request (including ability grp.) for 1st succeeding year
30	Five additional requests for 1st succeeding year
36	Six course requests for 2nd succeeding year
36	Six course requests for 3rd succeeding year
108	

Award Records

1	No. of times on Honor Roll or Scholastic Society in current year
1	No. of times during 1st year past
1	No. of times during 2nd year past
1	Special award or achievement code
4	Month and year awarded
25	Five more special awards codes and dates
33	

Student Activities Participation

9	Student Activity group involved
1	Participation level code
40	Four more student activities and participation codes
50	

Employment Experience

2	Current employment code
2	No. hours works per week currently
25	Current Employer name
2	Previous employment code
2	Previous No. hours works per week
25	Previous Employer name
29	Next previous experience in above format
87	

Vocational

1	1st choice occupational interest
1	2nd choice occupational interest
1	3rd choice occupational interest
1	1st selection job values
1	2nd selection job values
1	3rd selection job values
1	1st choice job type preference
1	2nd choice job type preference
1	3rd choice job type preference
1	1st choice entry job intention
1	2nd choice entry job intention
1	3rd choice entry job intention
1	1st appraisal of personal ability
1	2nd appraisal of personal ability
1	3rd appraisal of personal ability
15	

Disciplinary Actions

2	No. of times disciplinary action taken this year
2	No. of times sent home for the rest of the day only
2	No. of days under suspension for this year
5	Up to five 1-posn. illegal actions codes
11	

Interviews

1	Counseling priority required per students own estimate
1	Counseling priority assigned by counselor
2	

Vocational Interviews

6	Date of last interview
1	Time increments spent at last interview -- 5 minutes per increment
1	Interview results code
2	Total of all prior time increments for vocational interviews
10	

Academic Interviews

10	Same format as for vocational interviews

Behavioral Interviews

10	Same format as for vocational interviews

Personal Interviews

10	Same format as for vocational interviews

Attendance

2	Total absences for full day on Mondays during this year
8	Total absences for each other day of the week
10	Total absences for the previous school year
10	Full day cuts by date of week for this year
10	Period cuts by day of week for this year
20	Period cuts for the previous school year
190	Detail attendance day by day for this school year. One position for each day in school calendar
250	

Performance Forecasts

2	Percentile estimate of success for 1st subject area
22	Eleven additional subject area forecasts Note: Estimate obtained through formula analysis of test scores in intelligence and achievement areas, plus aptitude tests, correlated with grade point percentiles of marks received in each subject area and attendance.
24	

OTHER INFORMATION

Equipment Charged

4	Equipment type code
4	Date Issued on loan to student
6	Course with which used
14	Second piece of equipment on loan
28	

Textbooks Charged

8	Book Code
4	Date Issued on loan to student
6	Course with which used
180	Ten more books on loan
198	

Library Books Charged

8	Book Code
4	Date checked out of Library
120	Ten more books on loan
132	

Library Books read during year

8	Book Code of library book returned this year
392	Book Codes of 49 other books returned this year
400	

FILE NAME: SUBSTITUTES (applicable to certificated only)

SIZE	DATA ELEMENTS
	GENERAL INFORMATION
7	Substitute Number
9	Social Security Number
20	Substitute Name, last
15	Substitute Name, first
1	Substitute Name, middle initial
1	Sex
40	Address
10	Telephone Number
60	Subjects Willing and Able to Teach (up to 15)
20	Schools at which Substitute Prefers to Teach (up to 10)
42	Days and Times Willing to Teach
40	Special Considerations
265	

Educational Background

20	Degrees -- Areas and Year (up to 5)
5	Types of Certificates
60	Dates Issued and Expired
15	Special Qualifications (up to 5)
100	

Most Recent Experience

3	School
32	Subjects (up to 8)
12	Dates
3	Total Hours
1	Performance Code
20	Additional (to 5)
71	

Payroll

1	Rate Code
5	Pay Rate
27	Payroll Distribution (up to 3)
33	

Voluntary Deductions

2	Deduction Code No. 1
4	Deduction Amount No. 1
18	Above pattern three more times

Year-to-Date

7	Total Pay
4	Total Hours
6	Withholding Tax
5	FICA
2	Deduction Code No. 1
5	Deduction Amount No. 1
21	Above pattern three more times

This Period

4	Total Hours Worked
5	Withholding Tax
4	FICA
2	Deduction Code No. 1
4	Deduction Amount No. 1
18	Above pattern three more times

Personal

1	Handicap Code
6	Physical Exam, Date List
1	Award or Achievement Code
8	

FILE NAME: EMPLOYEE -- Certificated

Identification

SIZE	DATA ELEMENTS
7	Employee Number
9	Social Security Number
8	Certification Number
7	Retirement System Number
1	Retirement System Code
20	Name, last
15	first
15	middle
20	maiden
20	Address, Street Name and Number
20	City, State
6	City, zip code
7	Telephone Number (home)
1	Sex
1	Marital Status
6	Birthdate
25	Birthplace (City, State or County)
1	Citizenship Status
5	Census Tract
5	Precinct Code
3	Position Code, Primary
12	Position Code, additional (to 5)
1	New Teacher Code
3	Military Service (Years, Which Served)
218	

Location

3	Assignment
4	Location (School, Office, etc.)
2	Division Code
4	State Position Code
13	

Schedule

6	Subject and Section
42	Up to 7 More Periods
48	

Certification and Service

5	Types of Certificates
12	First (date issued, expired)
48	Additional (to 5)
2	Total Salary Credit Experience
2	Total Experience (years)
5	Experience, type (local or elsewhere)
45	Additional (to 10)
2	Salary Step
6	Date of Employment
6	Date of Termination
2	Reason for Termination
3	Special Qualifications
11	Last Merit Increase, Amount and Date
11	Last Increment, Amount and Date
3	Total Years of Training (and fraction of years)
1	Degrees, type
4	college
2	year
6	master
52	additional (to 4)
30	Subjects can Teach (5) + (1)
178	

Payroll

1	Contract Status
3	Contracted Days in work calendar
7	Contracted Salary Rate Annual
6	Monthly
5	Daily
4	Hourly
7	Additional Salary Amount and Code
7	Additional Salary Amount and Code
7	Additional Special Pay Adjustment (one time)
2	Vacation Days Authorized
3	Sick Leave Days Authorized
9	Payroll Distribution, Account number 1, factor
9	2, factor
9	3, factor
79	

Voluntary Deductions (Twelve Standard)

2	Deduction Code No. 1
4	Deduction Amount No. 1 per pay period
66	Above pattern eleven more times
72	

Year-to-Date

7	Gross, calendar
7	fiscal
7	contract
6	other pay
5	Days Actual
2	Compensated, contract
2	vacation
3	sick leave
3	leave, unpaid
6	Withholding Tax
5	FICA
7	Retirement System
2	Voluntary Deduction Code No. 1
5	Deduction Amount No. 1
77	Above pattern eleven more times
7	Net Amount (Fiscal)
151	

This Period

6	Gross Pay
6	Contract Pay
6	Other Pay
5	Withholding Tax
4	FICA
4	Retirement
2	Voluntary Deduction Code No. 1
4	Deduction Amount No. 1
66	Above pattern eleven more times
2	Days Compensated
2	Vacation Days
3	Sick Leave Paid
3	Not Paid
2	Leave, Unpaid
115	

Personal

6	Physical Exam, Date Last
6	X-Ray, Date Last
1	Rating Present
3	Last Three
1	Full or Part Time
1	Return to Corp Code
1	New Teacher Source Code
1	Handicap Code
1	Award or Achievement Code
1	Special Situation Status Code
22	

New Teacher Information

1	Preelection Rating
1	Reason for Selecting Area
2	Years Experience Allowed on Salary
1	Taught School Last Year (yes or no)
2	Years Experience (outside Area)
2	Years Experience (in Area)
9	

FILE NAME: EXPLOYEE FILE -- Non-Certificated

SIZE DATA ELEMENTS

Identification

7	Employee Number
9	Social Security Number
8	Classification Number
7	Retirement System Number
1	Retirement System Code
20	Name, last
15	first
15	middle
20	maiden
20	Address, Street Name and Number
20	City, State
6	Zip Code
5	Census Tract
5	Precinct Code
7	Telephone Number (home)
1	Marital Status
1	Sex
6	Birthdate
25	Birthplace (City, State or County)
1	Citizenship Status
3	Military Service (Years, Which Served)
3	Position Code, Primary
12	Additional (to 5)
217	

Location

3	Assignment
4	Location (school, office, etc.)
2	Division Code
4	State Position Code
13	

Service

2	Total Salary Credit Experience
2	Total Experience (Years)
5	Experience, Type (local or elsewhere)
45	Additional (to 10)
54	

Salary

2	Salary Step
6	Date of Employment
6	Date of Termination
2	Reason for Termination
3	Special Qualifications
11	Last Merit Increase, Amount and Date
11	Last Increment, Amount and Date
2	Total Years Schooling
1	Degrees, type
4	college
2	year
6	master
42	additional (to 4)
98	

Payroll

6	Time Period of Pay
7	Salary Schedule Rate, Annual
6	Monthly
5	Daily
4	Hourly
7	Additional Salary Amount and Code
7	Additional Salary Amount and Code
7	Additional Special Pay Adjustment (one time)
2	Vacation Days Authorized
3	Sick Leave Authorized
9	Payroll Distribution Account Number 1, Factor
9	2, Factor
9	3, Factor
81	

Voluntary Deductions (Twelve Standard)

3	Industrial Insurance
4	Bonds (Amount, Denomination)
4	UGN
4	First Medical
4	Second Medical
5	Optional Deductions
10	Dues and Code (up to 2)
2	Deduction Code No. 1
4	Deduction Amount No. 1 per pay period
66	Above pattern eleven more times
106	

Year-to-Date

7	Gross, Calendar
7	Fiscal
6	Other Pay
5	Days Actual
2	Compensated, Vacation
3	Sick Leave
3	Leave, Unpaid
6	Withholding Tax
5	FICA
7	Retirement System
2	Voluntary Deduction Code No. 1
5	Deduction Amount No. 1
77	Above pattern eleven more times
7	Net Amount (fiscal)
142	

This Period

6	Gross Pay
6	Other Pay
5	Withholding Tax
4	FICA
4	Retirement
2	Voluntary Deduction Code No. 1
4	Deduction Amount No. 1
66	Above pattern eleven more times
2	Days Compensated
2	Vacation Days
2	Sick Leave Paid
	Not Paid
2	Leave, Unpaid
105	

Personal

6	Physical Exam, Date Last
6	X-Ray, Date Last
1	Rating Present
3	Last Three
1	Full or Part Time
1	Handicap Code
1	Award or Achievement Code
1	Special Situation Status Code
20	

FILE NAME: EQUIPMENT

SIZE	DATA ELEMENTS
7	Item Number
10	Manufacturer's Serial Number
5	Item Class (projector, desk...)
30	Description (Grn Bell & Howell 35mm)

6	Location -- Building and Room
7	Responsible Person
8	Cost
8	Depreciated Value at End of Previous Accounting Period
2	Age at Delivery (years)
6	Date of Delivery
5	Vendor Number
5	Purchase Order Number
2	Estimated Life
1	Condition Code
1	Use Code (instruction, maintenance, surplus)
4	Date Warranty Expires
107	

FILE NAME: FACILITIES

SIZE DATA ELEMENTS

Locations Summary

4	Location Number
30	Name
40	Address
7	Telephone
7	Head Administrator
3	Classification (use)
1	Type Construction
6	Size (area)
8	Site Size
6	Floor Space
3	Class or Conference Rooms
1	Large Meeting Rooms
5	Capacity
5	Capacity
5	Capacity
1	Special Area
5	Capacity
1	Kitchen
5	Students, male
5	female
4	Certified Staff
4	Non-Certified Staff
4	Standard Student Capacity
4	Maximum Student Capacity
95	

Rooms

3	Location Number
4	Building Number
3	Room Number
3	Classification (use)
6	Floor Space
5	Maximum Capacity
5	Number of Seats
1	Limitations
1	Special
31	

FILE NAME: LIBRARY

SIZE DATA ELEMENTS

Textbook Control (one per textbook title)

2	Subject Area
3	Text Number
4	Number at School
4	Number on Order
4	Required This Year
4	Estimated Next Year's Requirement
4	Number Assigned to Teachers
4	Number Needing Repair or Replacement
5	Evaluation of Effectiveness
34	

FILE NAME: AUDIO-VISUAL MATERIALS

SIZE DATA ELEMENTS

General Information

6	Subject Area (3 maximum)
1	Type Procurement (rent, loan...)
5	Cost of Rental (per unit of rental time)
1	Time Period of Rental or Loan
5	Supplier Number
20	Title or Description
200	Synopsis
2	Audience Level (Adult, primary...)
6	Date Ordered or Purchased
6	Date to be Returned
7	Responsible Location
259	

Reservations -- Audio-Visual Material

5	Date Required
2	Days Required
4	Building
3	Room Number
7	Person Number
21	

Additional Reservations (variable)

FILE NAME: EDUCATIONAL SUPPLIES

SIZE	DATA ELEMENTS
7	Catalog No. (no in warehouse sequence)
8	Vendor Order Number
100	Description
1	Unit of Measure Code
3	Standard Pack
6	On Hand
6	On Order
6	Back-Ordered
6	Committed
6	Minimum Balance
7	Unit Cost
6	Year-to-Date Receipts
6	Year-to-Date Issues
6	Last Year's Usage
6	Number of Transactions Since Last Receipt
5	Date of Last Activity
6	Quantity Used Since Last Receipt
2	Lead Time in Weeks
4	Average Weekly Usage
6	Economic Order Quantity
5	Vendor Number
3	Shelf Life
211	

FILE NAME: COURSE

Courses Offered (one per course)

SIZE	DATA ELEMENTS
3	School Number
25	Course Title
4	Course Number
20	Prerequisites (up to 5)
2	Class Level
4	Laboratory or Concurrent Required Course, if any
2	Number of Sections Offered
60	

FILE NAME: CLASS

Individual Section Information (one per course section)

SIZE	DATA ELEMENTS
2	Section Number
3	Meeting Room
1	Period
1	Length
7	Teacher Number
3	Maximum Allowed in Section
3	Actual Number in Section
3	Textbooks Number
2	Volumes Issued
25	

APPENDIX D: COST DETAIL FOR MODEL REGIONS AND USOE REGION

DETAIL ANNUAL COST ESTIMATES

(Regions A, B, C, USOE)

Item	A	B	C	USOE
Central Site Equipment	(cost in thousands of dollars)			
1. Computing Equipment	302.0	382.6	528.4	528.4
2. Communications				
-Control Unit (DP mfg.)	31.8	42.9	76.5	73.5
-Adapter Unit (DP mfg.)	7.0	14.0	19.5	16.9
Total	38.8	56.9	96.0	90.4
-Comm. Line Term: Secondary Schools:				
.Comm. Adapter (DP mfg.)	18.2	37.0	55.2	48.0
.Common Carrier Term.	10.9	20.7	31.7	21.0
Total	29.1	57.7	86.9	69.0
-Comm. Line Term: Junior Colleges:				
.Comm. Adapter (DP mfg.)	.7	1.4	2.2	1.4
.Common Carrier Term.	.3	.7	1.0	.7
Total	1.0	2.1	3.2	2.1
-Comm. Line Term: Admin. Centers:				
.Comm. Adapter (DP mfg.)	1.0	1.9	2.9	1.9
.Common Carrier Term.	.4	.9	1.3	.9
Total	1.4	2.8	4.2	2.8
-Subtotal: Common Carrier	11.6	22.3	34.0	22.6
-Subtotal: DP mfg.	58.7	97.2	156.3	141.7
Total Comm.	70.3	119.5	190.3	164.3
3. Total Central Site				
-Subtotal: Common Carrier	11.6	22.3	34.0	22.6
-Subtotal: DP mfg.	360.7	479.8	684.7	670.1
Total	372.3	502.1	718.7	692.7
Secondary School				
1. DP mfg. supplied				
-Instructional Terminals	55.8	111.5	167.3	152.1
-Admin. Terminals	105.6	211.2	316.8	211.2
-Comm. Adapter	18.2	37.0	55.2	48.0
Total	179.6	359.7	539.3	411.3

DETAIL ANNUAL COST ESTIMATES (cont)

Item	A	B	C	USOE
Secondary School	(cost in thousands of dollars)			
2. Provided by Common Carrier				
-Comm. Lines	22.8	45.5	68.3	45.0
-Adapters and Term.	10.9	20.7	31.6	21.0
Total	33.7	66.2	99.9	66.0
3. Total Secondary Schools	213.3	425.9	639.2	477.3
Junior Colleges				
1. Provided by DP mfg.				
-Instructional Terminals	3.0	6.1	9.1	6.1
-Comm. Adapter	.7	1.4	2.1	1.4
Total	3.7	7.5	11.3	7.5
2. Provided by Common Carrier				
-Comm. Lines	.9	1.8	2.7	1.8
-Adapters and Term.	.3	.7	1.0	.7
Total	1.2	2.5	3.7	2.5
3. Total Junior Colleges	4.9	10.0	15.0	10.0
Administrative Centers				
1. DP Mfg.				
-Keyboard/Printer Terminals	4.1	8.1	12.2	8.1
-Comm. Adapter	1.0	1.9	2.9	1.9
Total	5.1	10.0	15.1	10.0
2. Provided by Common Carrier				
-Lines	.9	1.8	2.7	1.8
-Adapters and Term.	.4	.8	1.3	.8
Total	1.3	2.6	4.0	2.6
3. Total Administration Ctrs.	6.4	12.6	19.1	12.6
Total Equipment Costs				
-Common Carrier	47.8	93.6	141.6	93.7
-DP Mfg.	549.1	857.0	1,250.4	1,098.9
Total	596.9	950.6	1,392.0	1,192.6
Personnel and Supplies	195.0	252.0	285.0	263.0
Gross Total Annual Costs	791.9	1,202.6	1,677.0	1,455.6
Total Annual Operating Budget @ $532 Student	86,184.0	172,368.0	258,522.0	214,928.0
% of School Budget for DP services	0.86%	0.70%	0.65%	0.68%

DETAIL ANNUAL COST ESTIMATES (cont)

Item	A	B	C	USOE
Administrative Value				
Secondary Students				
1. Pupil Personnel Services @ $4.00/Student	160.0	320.0	480.0	400.0
2. Business Admin. Services @ $1.50/Student	60.0	120.0	180.0	150.0
Total	220.0	440.0	660.0	550.0
Elementary Students				
1. Business Admin. services @ $.50/Student	60.0	120.0	180.0	150.0
2. Testing: 37-1/2% of Students @ $.60/Student	27.0	54.0	81.0	67.5
Total	87.0	174.0	261.0	217.5
Total Administrative Value	307.0	614.0	921.0	767.5
Instructional Value (per student basis)				
Secondary Students				
1. Problem Solving	7.03	4.26	3.65	4.04
2. DP Training	4.30	2.61	2.23	2.47
Total	11.33	6.87	5.88	6.51
Junior College Students				
1. Problem Solving	8.96	5.44	4.65	5.20
2. DP Training	7.04	4.27	3.65	4.09
Total	16.00	9.77	8.31	9.29
Instructional Value for Total Enrollment	484.9	588.6	756.0	688.1

APPENDIX E: COST DETAIL FOR CASE STUDY REGION

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION

ITEM		CASE STUDY REGION COST
CENTRAL SITE EQUIPMENT		
1. Computing Equipment		$ 382,614
2. Communications		
-Control Unit (DP Mfg.)		73,533
-Communications Adapter Units (DP Mfg.)		16,896
-Communications Line Terminals: Secondary Schools		
.D.C. Schools Communications Adapter (DP Mfg.)		8,880
.Alexandria Communications Adapter (DP Mfg.)		2,160
.Arlington Communications Adapter (DP Mfg.)		3,600
.Fairfax Communications Adapter (DP Mfg.)		16,080
.Falls Church Communications Adapter (DP Mfg.)		480
.Montgomery Communications Adapte (DP Mfg.)	14,160	
Common Carrier Terminals	600	14,760
-Communications Line Terminals: Junior Colleges		
.Montgomery Communications Adapter (DP Mfg.)		1,200
.Northern Virginia Communications Adapter (DP Mfg.)		720
-Communications Line Terminals: Administrative Centers		
.D.C. Schools Communications Adapter (DP Mfg.)		$ 960
.Alexandria Communications Adapter (DP Mfg.)		480
.Arlington Communications Adapter (DP Mfg.)		480
.Fairfax Communications Adapter (DP Mfg.)		960
.Falls Church Communications Adapter (DP Mfg.)		240
.Montgomery Communications Adapter (DP Mfg.)		960
TOTAL COMMUNICATIONS		
-Common Carrier Subtotal		600
-DP Mfg. Subtotal		141,789
TOTAL		142,389
3. TOTAL CENTRAL SITE		
-Common Carrier Subtotal		600
-DP Mfg. Subtotal		524,403
TOTAL		525,003
SECONDARY SCHOOL EQUIPMENT		
1. D. C. Schools		
-DP Mfg. supplied		
.Instructional Terminals		26,364
.Administrative Terminals		46,464
.Communications Adapter		8,880
TOTAL		81,708

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (Cont)

ITEM	CASE STUDY REGION COST
SECONDARY SCHOOL EQUIPMENT (Continued)	
-Provided by Common Carrier	
.Communications Lines	$ 2,514
TOTAL	2,514
-D.C. Schools Total	84,222
2. Alexandria	
-DP Mfg. Supplied	
.Instructional Terminals	6,084
.Administrative Terminals	12,672
.Communications Adapters	2,160
TOTAL	20,916
-Provided by Common Carrier	
.Communications Lines	947
.Adapters and Termination	270
TOTAL	1,217
-Alexandria Total	22,133
3. Arlington	
-DP Mfg. Supplied	
.Instructional Terminals	12,168
.Administrative Terminals	12,672
.Communications Adapter	3,600
TOTAL	28,440
-Provided by Common Carrier	
.Communications Lines	922
.Adapters and Termination	360
TOTAL	1,282
-Arlington Total	29,722
4. Fairfax	
-DP Mfg. Supplied	
.Instructional Terminals	50,700
.Administrative Terminals	71,808
.Communications Adapters	16,080
TOTAL	138,588
-Provided by Common Carrier	
.Communications Lines	7,924
.Adapters and Termination	1,890
TOTAL	9,814
-Fairfax Total	148,402
5. Falls Church	
-DP Mfg. Supplied	
.Instructional Terminals	1,014
.Administrative Terminals	4,224
.Communications Adapters	480
TOTAL	5,718
-Provided by Common Carrier	
.Communications Lines	$ 252
.Adapters and Termination	90
TOTAL	342
-Falls Church Total	6,060
6. Montgomery	
-DP Mfg. Supplied	
.Instructional Terminals	44,616
.Administrative Terminals	71,808
.Communications Adapters	14,160
TOTAL	130,578
-Provided by Common Carrier	
.Communications Lines	6,621
.Adapters and Termination	6,318
TOTAL	12,939
-Montgomery Total	143,517
7. Secondary Schools Total	
-DP Mfg. Supplied	405,948
-Provided by Common Carrier	28,108
TOTAL	434,056
JUNIOR COLLEGE EQUIPMENT	
1. Montgomery	
-DP Mfg. Supplied	
.Instructional Terminals	5,070
.Communications Adapters	1,200
TOTAL	6,270
-Provided by Common Carrier	
.Communications Lines	551
.Adapters and Termination	360
TOTAL	911
-Montgomery Total	7,181
2. Northern Virginia	
-DP Mfg. Supplied	
.Instructional Terminals	3,042
.Communications Adapters	720
TOTAL	3,762
-Provided by Common Carrier	
.Communications Lines	245
.Adapters and Termination	90
TOTAL	335
-Northern Virginia Total	4,097

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (cont)

ITEM	CASE STUDY REGION COST
JUNIOR COLLEGE EQUIPMENT (Continued)	
3. Junior College Total	
-DP Mfg. Supplied	$ 10,032
-Provided by Common Carrier	1,246
TOTAL	11,278
ADMINISTRATIVE CENTER EQUIPMENT	
1. D.C. Schools	
-DP Mfg. Supplied	
. Keyboard/Printer Terminals	4,056
. Communications Adapters	960
TOTAL	5,016
-Provided by Common Carrier	
. Communications Lines	187
TOTAL	187
-D.C. Schools Total	5,203
2. Alexandria	
-DP Mfg. Supplied	
. Keyboard/Printer Terminals	2,028
. Communications Adapters	480
TOTAL	2,508
-Provided by Common Carrier	
. Communications Lines	316
. Adapters and Terminals	90
TOTAL	406
-Alexandria Total	2,914
3. Arlington	
-DP Mfg. Supplied	
. Keyboard/Printer Terminal	2,028
. Communications Adapters	480
TOTAL	2,508
-Provided by Common Carrier	
. Communications Lines	158
. Communications Adapters	90
TOTAL	248
-Arlington Total	2,756
4. Fairfax	
-DP Mfg. Supplied	
. Keyboard/Printer Terminal	4,056
. Communications Adapters	960
TOTAL	5,016
-Provided by Common Carrier	
. Communications Lines	$ 497
. Adapters and Terminals	90
TOTAL	587
-Fairfax Total	5,603
5. Falls Church	
-DP Mfg. Supplied	
. Keyboard/Printer Terminal	1,041
. Communications Adapter	240
TOTAL	1,254
-Provided by Common Carrier	
. Communications Lines	252
. Adapters and Termination	90
TOTAL	342
-Falls Church Total	1,596
6. Montgomery	
-DP Mfg. Supplied	
. Keyboard/Printer Terminal	4,056
. Communications Adapter	960
TOTAL	5,016
-Provided by Common Carrier	
. Communications Lines	374
. Adapters and Termination	270
TOTAL	644
-Montgomery Total	5,660
7. Administrative Center Total	
-DP Mfg. Supplied	21,318
-Provided by Common Carrier	2,414
TOTAL	23,732
TOTAL EQUIPMENT COSTS	
-Common Carrier	32,368
-DP Mfg.	961,701
PERSONNEL AND SUPPLIES	252,000
GROSS TOTAL ANNUAL COSTS	1,246,069

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (cont)

ITEM	CASE STUDY REGION COST
CASE STUDY REGION OPERATING BUDGETS	
1. Secondary Schools	
-D. C. Schools	$ 82,268,000
-Alexandria	9,702,800
-Arlington	21,198,288
-Fairfax	54,255,730
-Falls Church	1,535,462
-Montgomery	74,787,059
TOTAL	243,747,339
2. Junior Colleges (Instruction only)	
-Montgomery Junior College	2,062,509
-Northern Virginia Community College	1,208,600
TOTAL	3,271,109
3. Total Operating Budgets	247,018,448
% of Budget for DP Services	.50%
ADMINISTRATIVE VALUES	
1. Secondary Students	
-Pupil Personnel Services @ $4.00 per student	344,668
-Business Administrative Services @ $1.50 per student	$ 129,250
TOTAL	473,918
2. Elementary Students	
-Business Administrative Services @ $.50 per student	159,237
-Testing 37-1/2% of students @ $.60 per student	71,656
TOTAL	230,893
3. Total Administrative Value	704,811
INSTRUCTIONAL VALUES	
1. Secondary Students	
-Problem Solving @ $5.95 per student	512,571
2. Junior College Students	
-Problem Solving @ $7.18 per full-time student (4,025)	28,687
3. Total Instructional Value	541,258

APPENDIX F: SIMULATION

Addendum 1

System Configuration Simulated, by Model Region

Model region	A	B	C	USOE
Terminals simulated				
*Type 2741	68	135	203	167
Type 1050	25	50	75	50
System/360				
Model	40H	50M	50I	50I
Relative processing speed	0.4	1.0	1.0	1.0
Core Allocation (1000's of bytes)				
Problem-solving supervisor	70	70	70	70
Student workspaces (18,000 bytes each)	90	90	288	288
DOS with modifications	25	25	25	25
QTAM	5	5	5	5
Adm inquiry programs (12,000 bytes ea.)	36	36	84	84
**Line buffer poll	30	30	30	30
Total	256	256	502	502

Addendum 2

Problem Solving

Distribution of Student Response Times

15-Point Continuous Distribution Function = 56.2 seconds

Cumulative Probability	Student Response Time, seconds
.00	2.5545
.06	5.1090
.21	10.2180
.32	15.3270
.41	20.4360
.54	30.6540
.63	40.8720
.69	51.0900
.77	71.5260
.83	91.9620
.88	127.7250
.95	212.0235
.98	293.7675
.99	370.4025
1.00	510.9000

Addendum 3

Problem Solving

Distribution of Calculation Time Required on 360/50

10-Point continuous distribution function
Mean = 25 seconds

Cumulative Probability	Calculate Time Required, seconds
.000	.01
.780	.10
.830	.20
.850	.30
.880	.50
.940	1.00
.960	1.30
.970	1.70
.974	2.00
1.000	6.25

---

*All problem-solving sessions were simulated at these terminals, which were operating continuously, and which generated the same average number of sessions as the actual larger number of terminals operating on a scheduled basis.

**This amount of buffer storage was judged to be adequate, although the operation of this dynamic buffer pool was not simulated.

Addendum 4

Problem Solving

Distribution of Message Lengths, Terminal to Processor

4-Point Continuous Distribution Function
Mean = 17.5 Characters

Cumulative Probability	Characters
.0	2
.5	10
.8	20
1.0	80

Addendum 5

Problem Solving

Distribution of Message Lengths, Processor to Terminal

4-Point Continuous Distribution Function
Mean = 8.75 Characters

Cumulative Probability	Characters
.0	1
.5	5
.8	10
1.0	40

Addendum 6

Problem Solving

Distribution of Message Types

4-Point Discrete Probability Function

Message Type	Function
1	Sign on (beginning of session) (Not handled by this function)
2	Load (previously saved workspace)
3	Drop (previously saved workspace) Add (new user)
4	Save (current workspace) Off (end session and save workspace) Copy (requested information from saved workspace)
5	Calculate (interpreter)

Cumulative Probability	Message Type
.028	2
.033	3
.066	4
1.000	5

Addendum 7

Administrative Inquiry

Mean Inter-origination times for beginning segments of administrative messages, terminal to processor, seconds. Characters/segment. Number of segments.

	Mean Inter-origination, seconds					Input		Output	
	A	B	C	USOE	Case Study	Char/ Seg	No. of Seg	Char/ Seg	No. of Seg
Cuts	23.4	11.7	7.8	9.3	10.9	10	1	100	1
Absence Reason Update	7.8	3.9	2.6	3.1	3.6	10	1	24	1
Tardies -- Early Dismissal	58.5	29.2	19.5	23.4	27.2	12	1	24	1
New Student Registrations	292.5	146.2	97.5	117.0	136.0	100	5	24	1
Leaving Students	292.5	146.2	97.5	117.0	136.0	10	2	24	1
Program Changes	58.5	29.2	19.5	23.4	27.2	10	2	24	1
Guidance Requests	58.5	29.2	19.5	23.4	27.2	10	2	500	5

Addendum 8

Administrative Inquiry

Distribution, Exponential, used to calculate inter-origination times for beginning segments of administrative messages, terminal to processor.

24-Point Continuous Distribution Function

Cumulative Probability	Factor	Cumulative Probability	Factor
.0000	.0000	.9000	.2300
.1000	.0104	.9200	.2520
.2000	.0222	.9400	.2810
.3000	.0355	.9500	.2990
.4000	.0509	.9600	.3200
.5000	.0690	.9700	.3500
.6000	.0915	.9800	.3900
.7000	.1200	.9900	.4600
.7500	.1380	.9950	.5300
.8000	.1600	.9980	.6200
.8400	.1830	.9990	.7000
.8800	.2120	.9997	.8000

Addendum 9

Problem-Solving Model

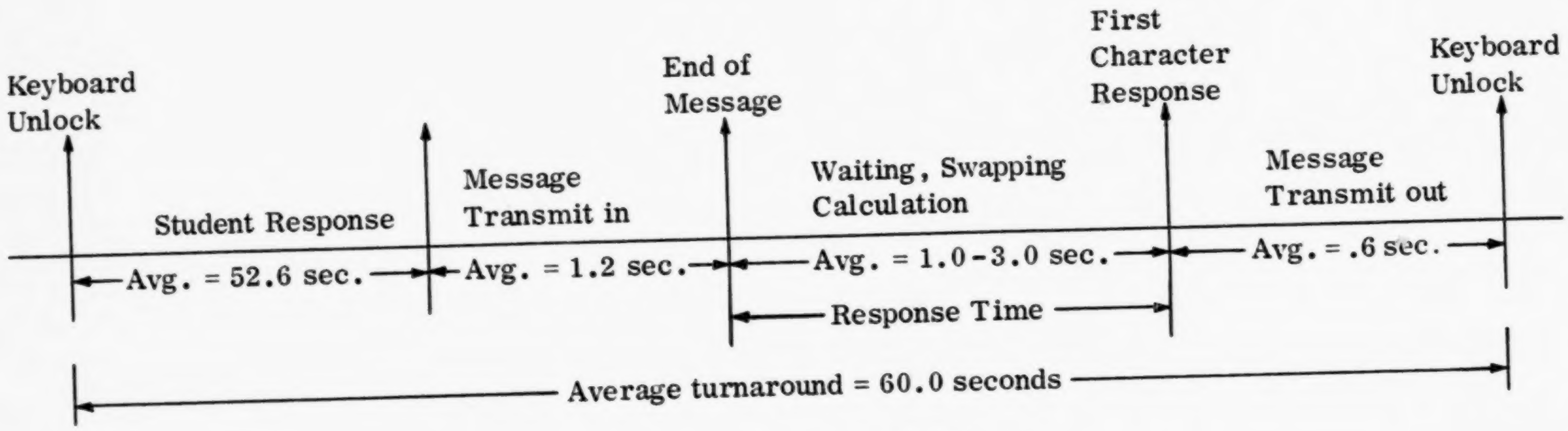
Following the processing of a problem-solving device interrupt, control is given to the problem-solving scheduler to determine if there is some new task which can be performed. When an administrative device interrupt occurs, control is given to the administrative scheduler if the system has been idle, or control returns to the interrupted process if the system has been busy.

The problem-solving scheduler first initiates a "swap" operation, if necessary. Swapping is an integral part of time-sharing and results in a flow or workspaces from main storage to direct access storage and from direct access storage back in main storage. Swapping removes those inactive workspaces from main storage for which there is no current request pending. When there are no inactive workspaces in main storage, but there is an active workspace in direct access storage, then the workspace swapped out is the one which has received the largest amount of processing time since its original entry into main storage for the CPU to service; that is, for as long as a peak demand persists.

When a user workspace is selected to use the CPU, a maximum time slice of 100 milliseconds is provided. This, in conjunction with the swapping operation, gives short-duration jobs priority over long-duration jobs. The net result is a lower average response time than if all requests had been queued and processed serially. A user expects a quick response to a simple request. However, he must be content to wait longer to receive the results of a complex operation.

If there are no swaps to be initiated, the problem-solving supervisor checks to see if there are any active workspaces in main storage. If so, the workspace is selected which has received the least number of time slices since its original arrival in main storage. Control is then given to the problem-solving language processor, which begins the processing of the current request or resumes processing where it has been interrupted. If there are no active workspaces in main storage, control is passed to the administrative scheduler.

The overall sequence of events associated with a single student request, in the environment as well as within the processor, is as shown.


Keyboard Unlock
Student Response
Avg. = 52.6 sec.
Message Transmit in
Avg. = 1.2 sec.
End of Message
Waiting, Swapping Calculation
Avg. = 1.0-3.0 sec.
Response Time
First Character Response
Message Transmit out
Avg. = .6 sec.
Keyboard Unlock
Average turnaround = 60.0 seconds

Problem-solving 1/0 cycle

Response time is defined as the total time between end of message and receipt of the first response character from the computer. After the last character has been typed out, the keyboard unlocks and the user decides what his next entry is to be. He then enters this message and depresses the end-of-message key. Next, the computer performs the requested operation and sends a message back to the terminal. These messages are assumed to be random in function, length, frequency, and CPU processing requirements.

To characterize these random messages, the simulator uses random number generators and modified empirical functions. In this manner, the "conversation" between the user and the computer is simulated. There are as many concurrent conversations in the simulation as there are active problem-solving terminals.

In order to obtain the required first response, the problem-solving supervisor must be optimized to handle these specialized functions with the least possible overhead. The currently implemented APL/360 supervisor consumes less than .1% of the CPU time. Based on this, the problem-solving supervisor overhead was considered negligible and not simulated.

Administrative Inquiry Model

This model calculates the average time between message generations of each task, and simulates sending these messages from the terminals to the central processing unit. The input is handled by a communication control program, which queues the messages in priority sequence. (Attendance tasks are assigned highest priority; guidance, intermediate; and registration, lowest.)

When the problem-solving scheduler has no tasks for the central processing unit, the DOS/360 scheduler checks the input queue for administrative messages to be processed. If there is administrative input, a task is activated, processed by the appropriate message-processing program, and the response is placed on a message output queue. The response is subsequently sent to the originating terminal by the communication control program, as central processing unit time becomes available.

Processing times were modeled for all message-processing programs, as well as the communication control program and all functions of DOS/360.

Addendum 10

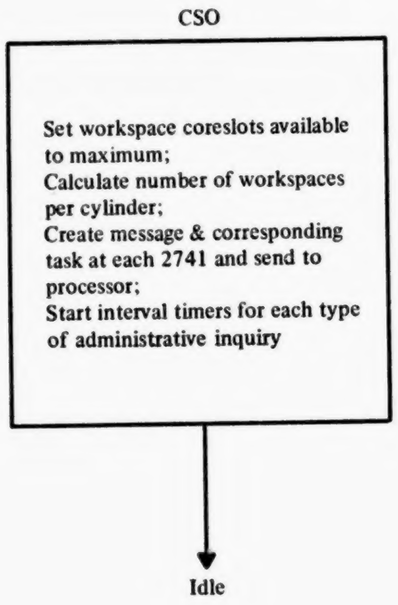
Flowcharts of Simulation Model

The special terms used in the flowcharts are defined below:

ALG0, 1, 2	Parameters that adjust the priorities for the selection of workspaces to be swapped from disk to core. ALG0 = 0, ALG1 = 1, ALG2 = 2
PERCORE	Array of identifiers of student workspaces located in core
PERDISK	Array of identifiers of student workspaces on swap disks
ARM	Cylinder location of disk access arm on swap disk
MAXARM	Last cylinder location in use on swap disk
QUONT	Number of time slices a student workspace has received since it last entered core
QUONTMIN QUONTMAX	Minimum and maximum values of QUONT used for controlling the selection of student workspaces for processing and for swapping, respectively

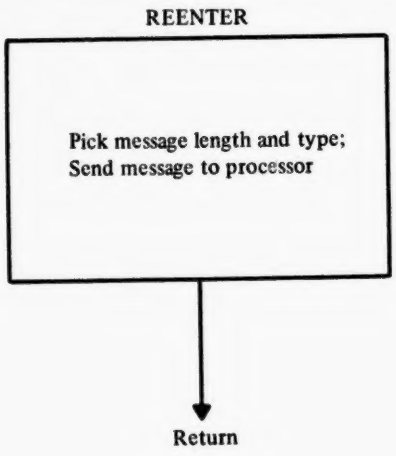
Process times shown in the flowcharts are for a 360/50. Multiply by 2.5 to obtain those used to simulate a 360/40.

INITIALIZATION

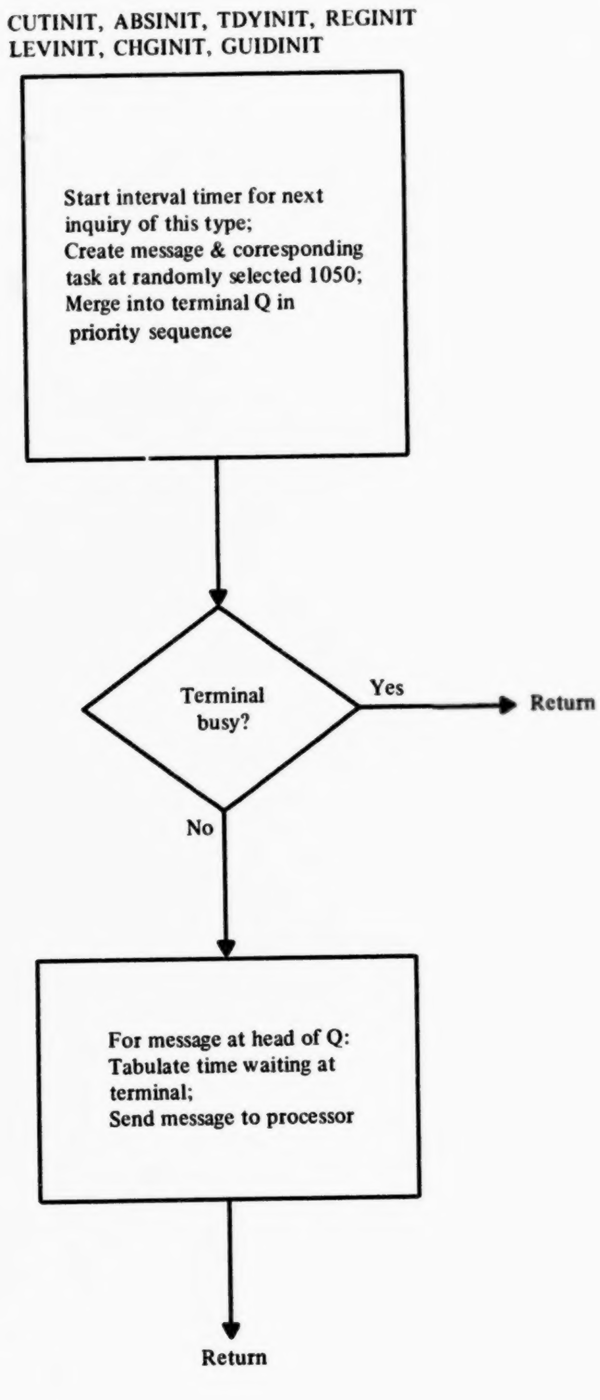

CSO
Set workspace coreslots available to maximum;
Calculate number of workspaces per cylinder;
Create message & corresponding task at each 2741 and send to processor;
Start interval timers for each type of administrative inquiry
Idle

ENVIRONMENT INTERRUPTS

Student response interval timer timeout:

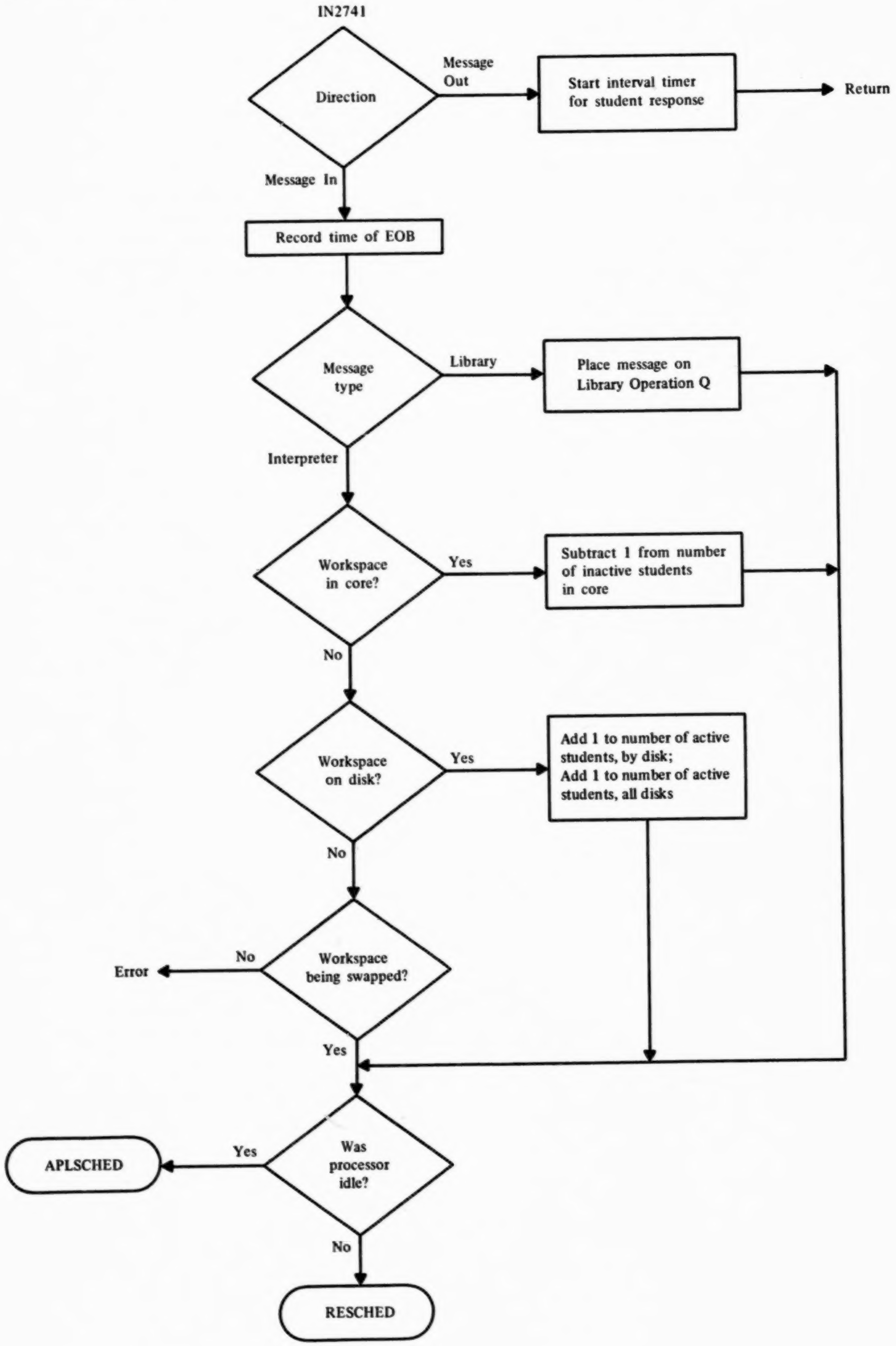

REENTER
Pick message length and type;
Send message to processor
Return

Administrative inquiry interval timer timeout:

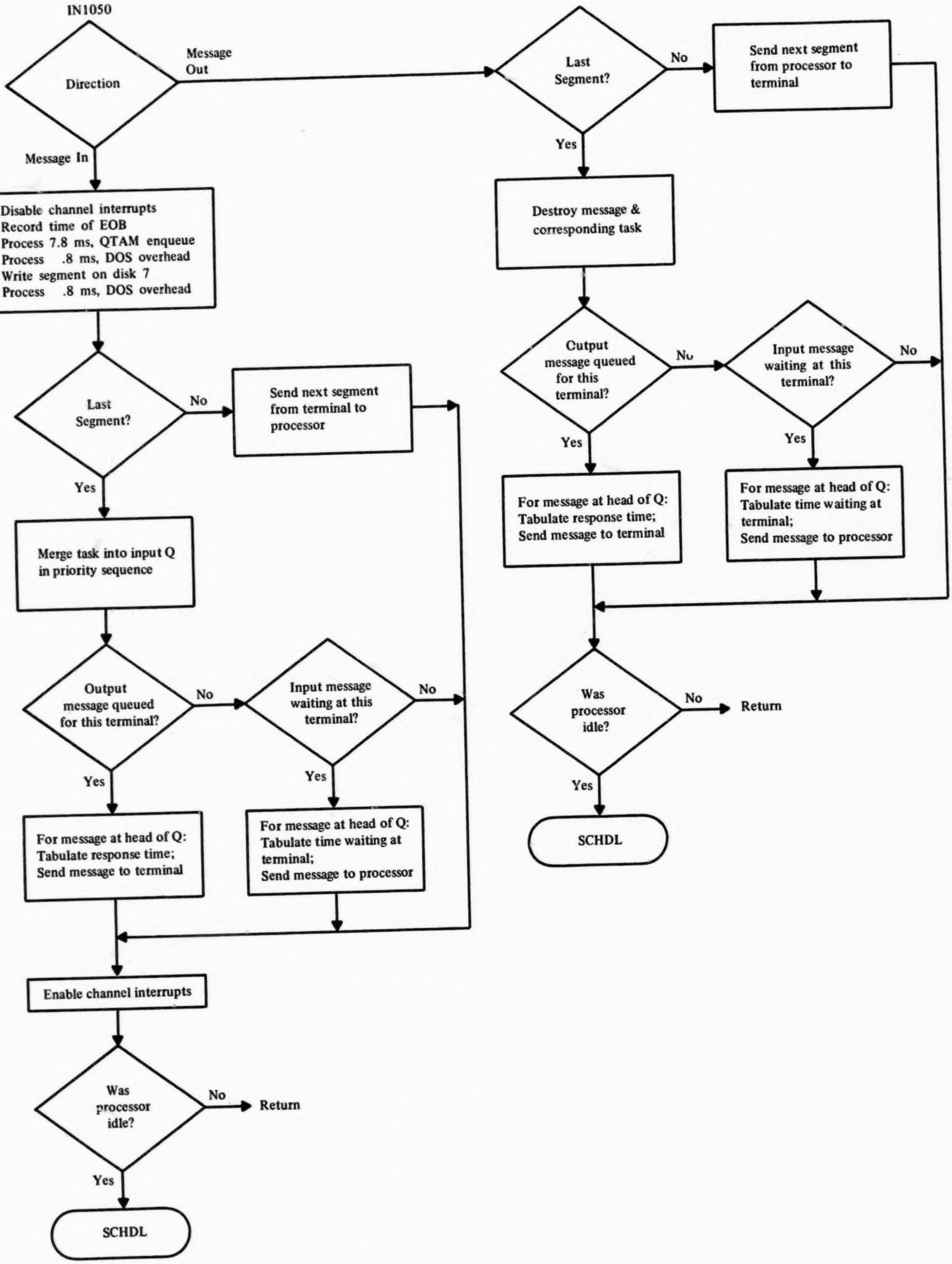

CUTINIT, ABSINIT, TDYINIT, REGINIT
LEVINIT, CHGINIT, GUIDINIT
Start interval timer for next inquiry of this type;
Create message & corresponding task at randomly selected 1050;
Merge into terminal Q in priority sequence
Terminal busy?
Yes
Return
No
For message at head of Q:
Tabulate time waiting at terminal;
Send message to processor
Return

PROCESSOR INTERRUPTS

Multiplexer channel, 2741:

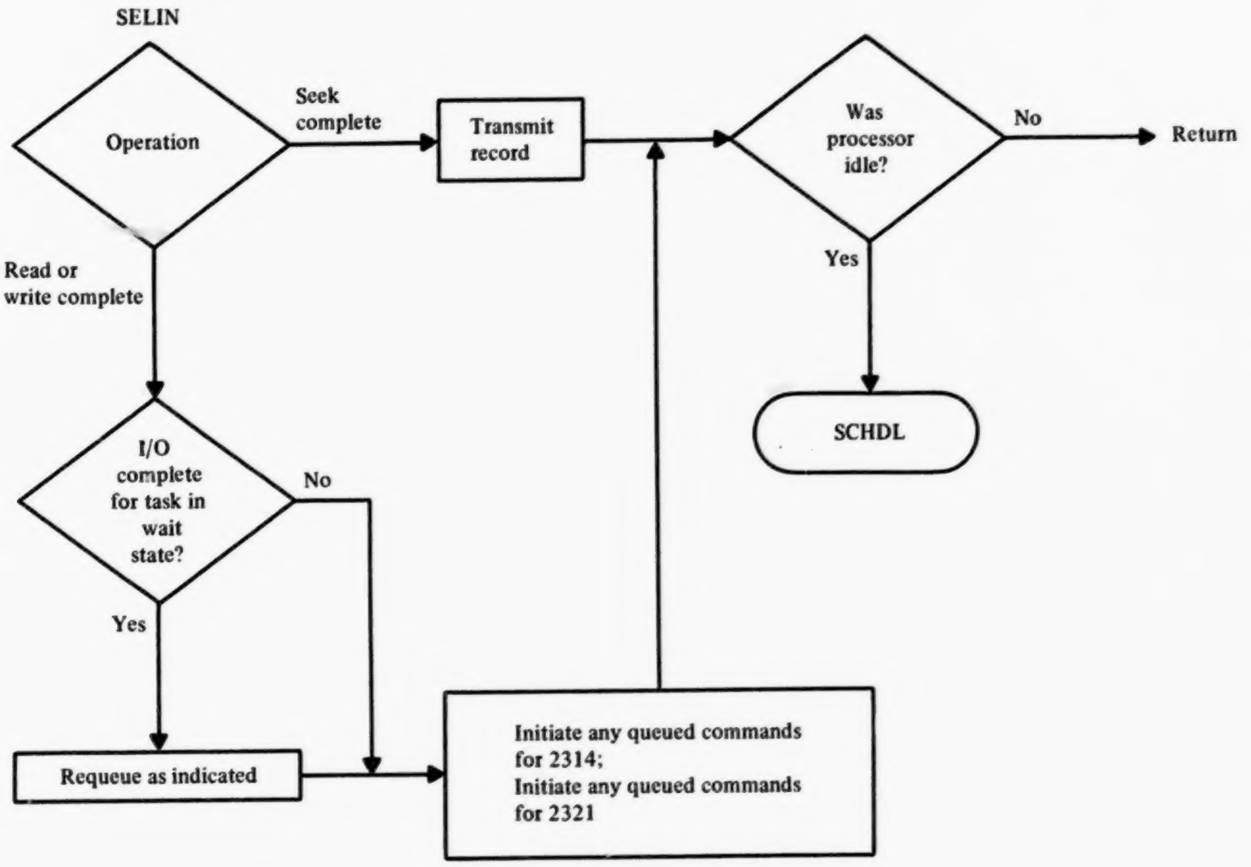

IN2741
Direction
Message Out
Start interval timer for student response
Return
Message In
Record time of EOB
Message type
Library
Place message on Library Operation Q
Interpreter
Workspace in core?
Yes
Subtract 1 from number of inactive students in core
No
Workspace on disk?
Yes
Add 1 to number of active students, by disk;
Add 1 to number of active students, all disks
No
Workspace being swapped?
No
Error
Yes
Was processor idle?
Yes
APLSCHED
No
RESCHED

PROCESSOR INTERRUPTS (CONT'D)
Multiplexer channel: 1050

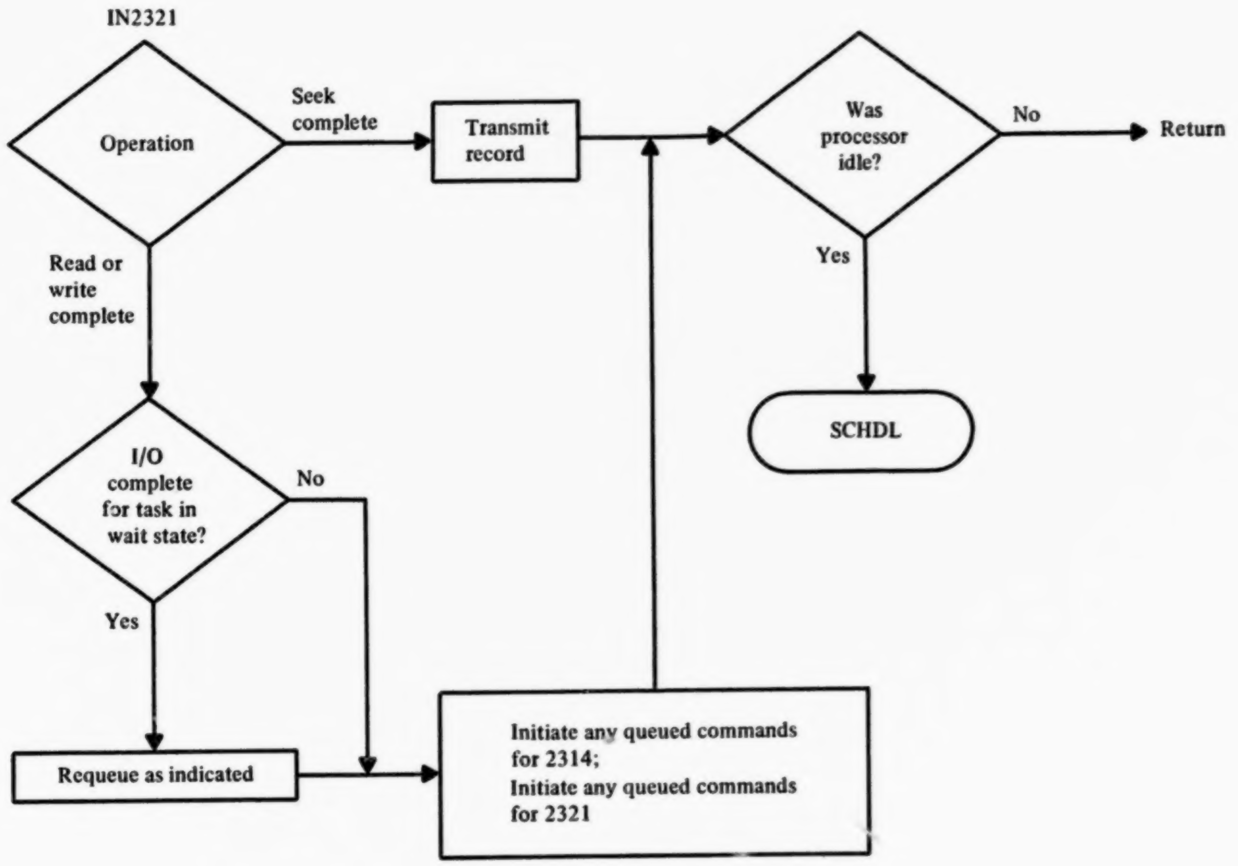

IN1050
Direction
Message Out
Message In
Disable channel interrupts
Record time of EOB
Process 7.8 ms, QTAM enqueue
Process .8 ms, DOS overhead
Write segment on disk 7
Process .8 ms, DOS overhead
Last Segment?
No
Send next segment from terminal to processor
Yes
Merge task into input Q in priority sequence
Output message queued for this terminal?
No
Input message waiting at this terminal?
No
Yes
Yes
For message at head of Q: Tabulate response time; Send message to terminal
For message at head of Q: Tabulate time waiting at terminal; Send message to processor
Enable channel interrupts
Was processor idle?
No
Return
Yes
SCHDL
Last Segment?
No
Send next segment from processor to terminal
Yes
Destroy message & corresponding task
Output message queued for this terminal?
No
Input message waiting at this terminal?
No
Yes
Yes
For message at head of Q: Tabulate response time; Send message to terminal
For message at head of Q: Tabulate time waiting at terminal; Send message to processor
Was processor idle?
No
Return
Yes
SCHDL

PROCESSOR INTERRUPTS (CONT'D)

Selector channel, 2314, administrative inquiry disk:

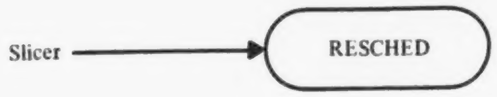

SELIN
Operation
Seek complete
Transmit record
Was processor idle?
No
Return
Yes
SCHDL
Read or write complete
I/O complete for task in wait state?
No
Yes
Requeue as indicated
Initiate any queued commands for 2314;
Initiate any queued commands for 2321

Selector channel, 2321:

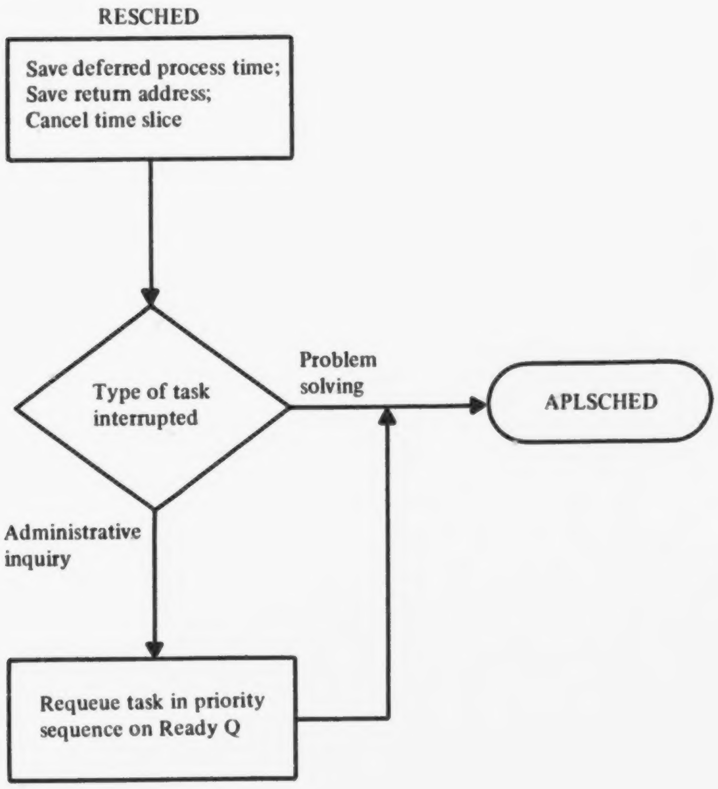

IN2321
Operation
Seek complete
Transmit record
Was processor idle?
No
Return
Yes
SCHDL
Read or write complete
I/O complete for task in wait state?
No
Yes
Requeue as indicated
Initiate any queued commands for 2314;
Initiate any queued commands for 2321

PROCESSOR INTERRUPTS (CONT'D

Time slice interval timer timeout:

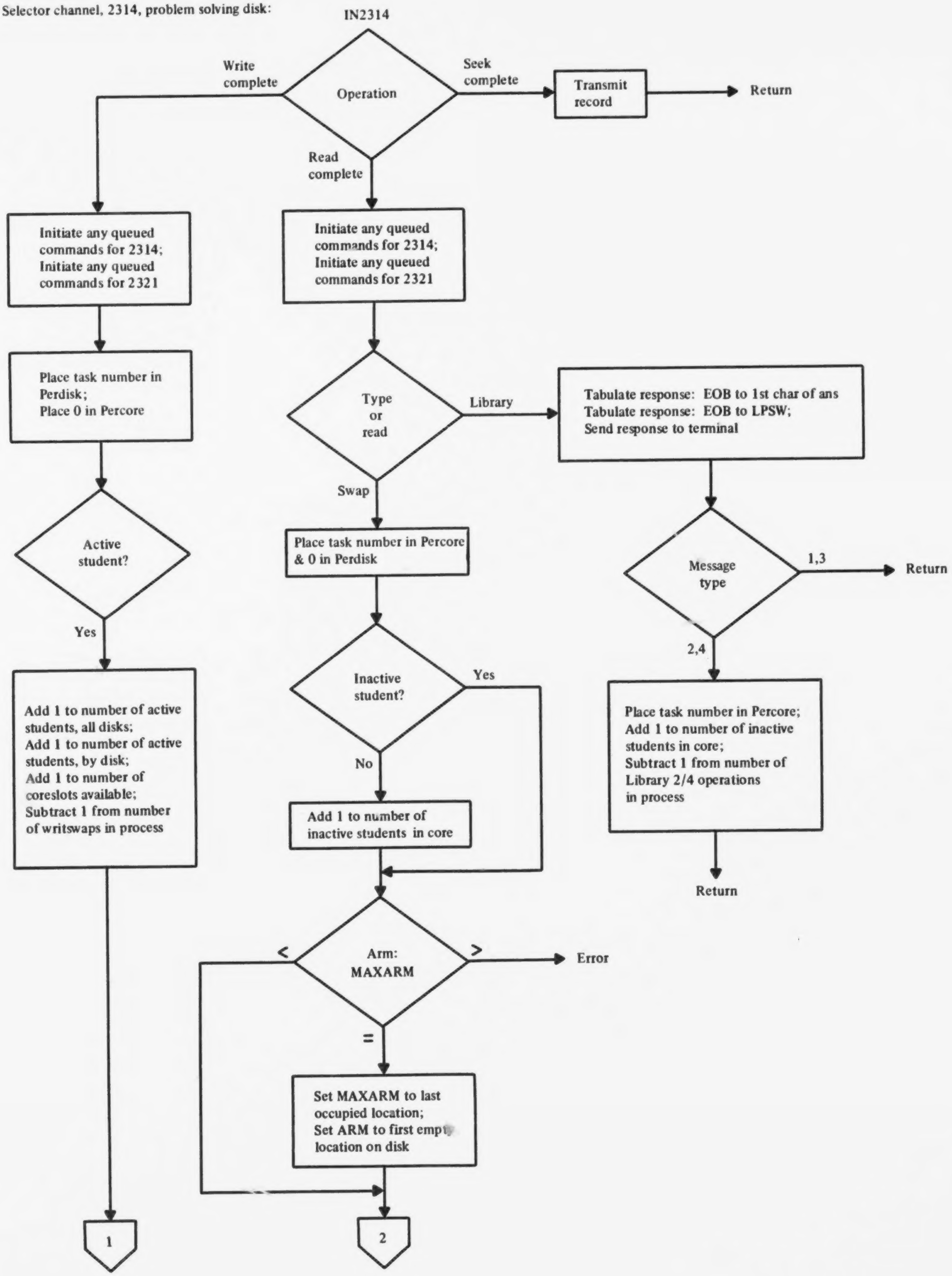

Slicer
RESCHED

Problem solving I/O interrupt rescheduler:

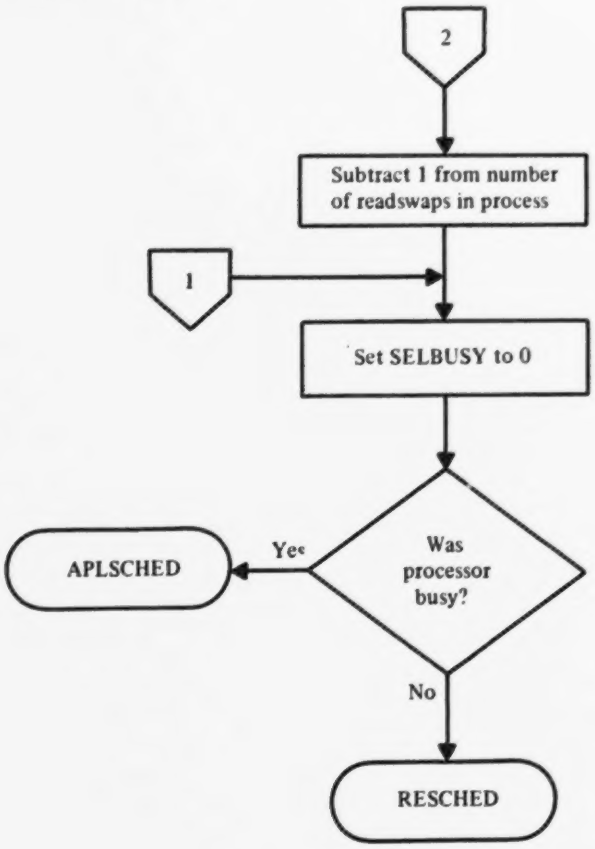

RESCHED
Save deferred process time;
Save return address;
Cancel time slice
Type of task interrupted
Problem solving
APLSCHED
Administrative inquiry
Requeue task in priority sequence on Ready Q

PROCESSOR INTERRUPTS (CONT'D)

Selector channel, 2314, problem solving disk:

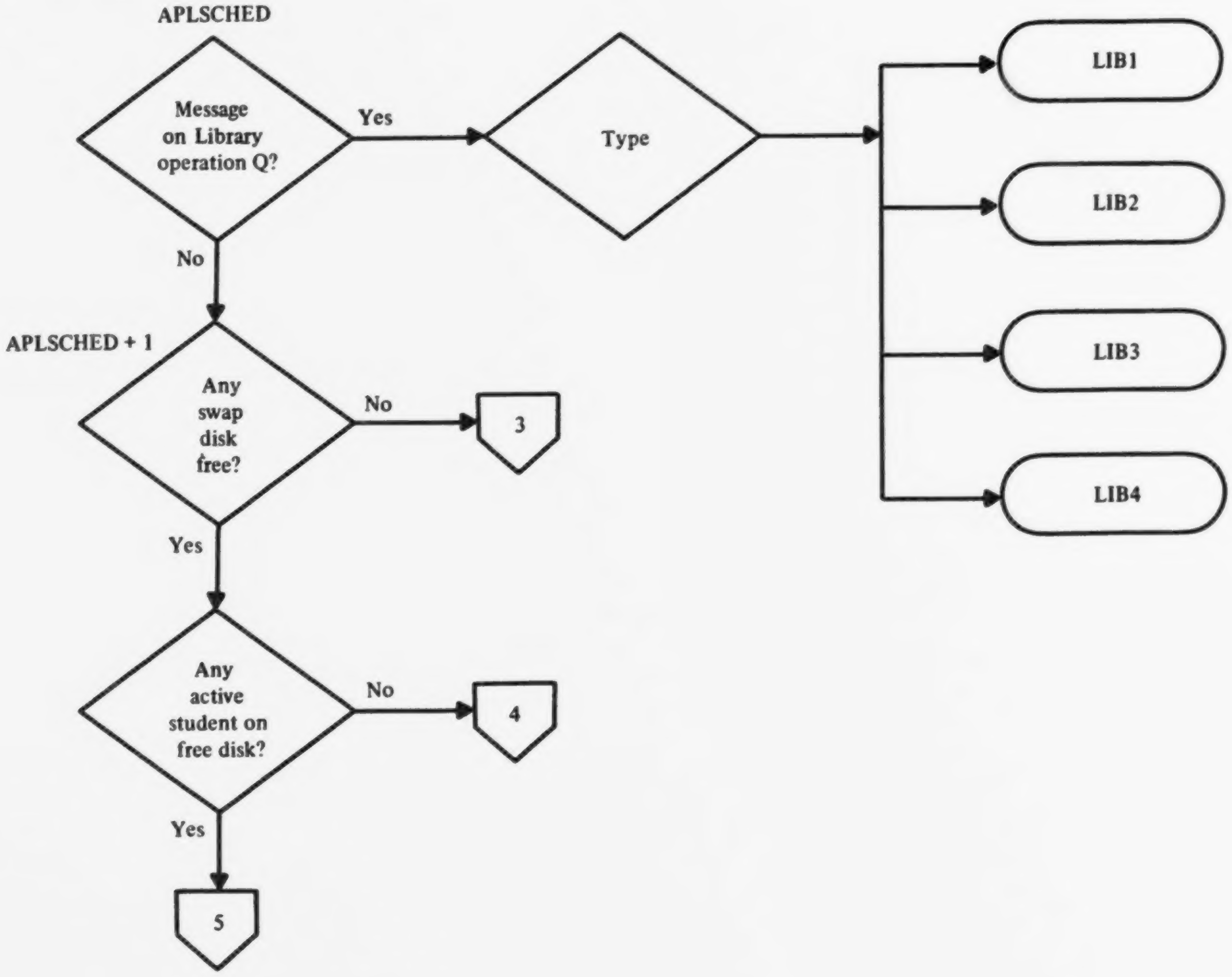

IN2314
Operation
Write complete
Seek complete
Read complete
Transmit record
Return
Initiate any queued commands for 2314; Initiate any queued commands for 2321
Initiate any queued commands for 2314; Initiate any queued commands for 2321
Place task number in Perdisk; Place 0 in Percore
Type or read
Library
Swap
Tabulate response: EOB to 1st char of ans
Tabulate response: EOB to LPSW;
Send response to terminal
Active student?
Yes
Place task number in Percore & 0 in Perdisk
Message type
1,3
Return
2,4
Add 1 to number of active students, all disks; Add 1 to number of active students, by disk; Add 1 to number of coreslots available; Subtract 1 from number of writswaps in process
Inactive student?
Yes
No
Add 1 to number of inactive students in core
Place task number in Percore; Add 1 to number of inactive students in core; Subtract 1 from number of Library 2/4 operations in process
Return
Arm: MAXARM
<
>
Error
=
Set MAXARM to last occupied location; Set ARM to first empty location on disk
1
2

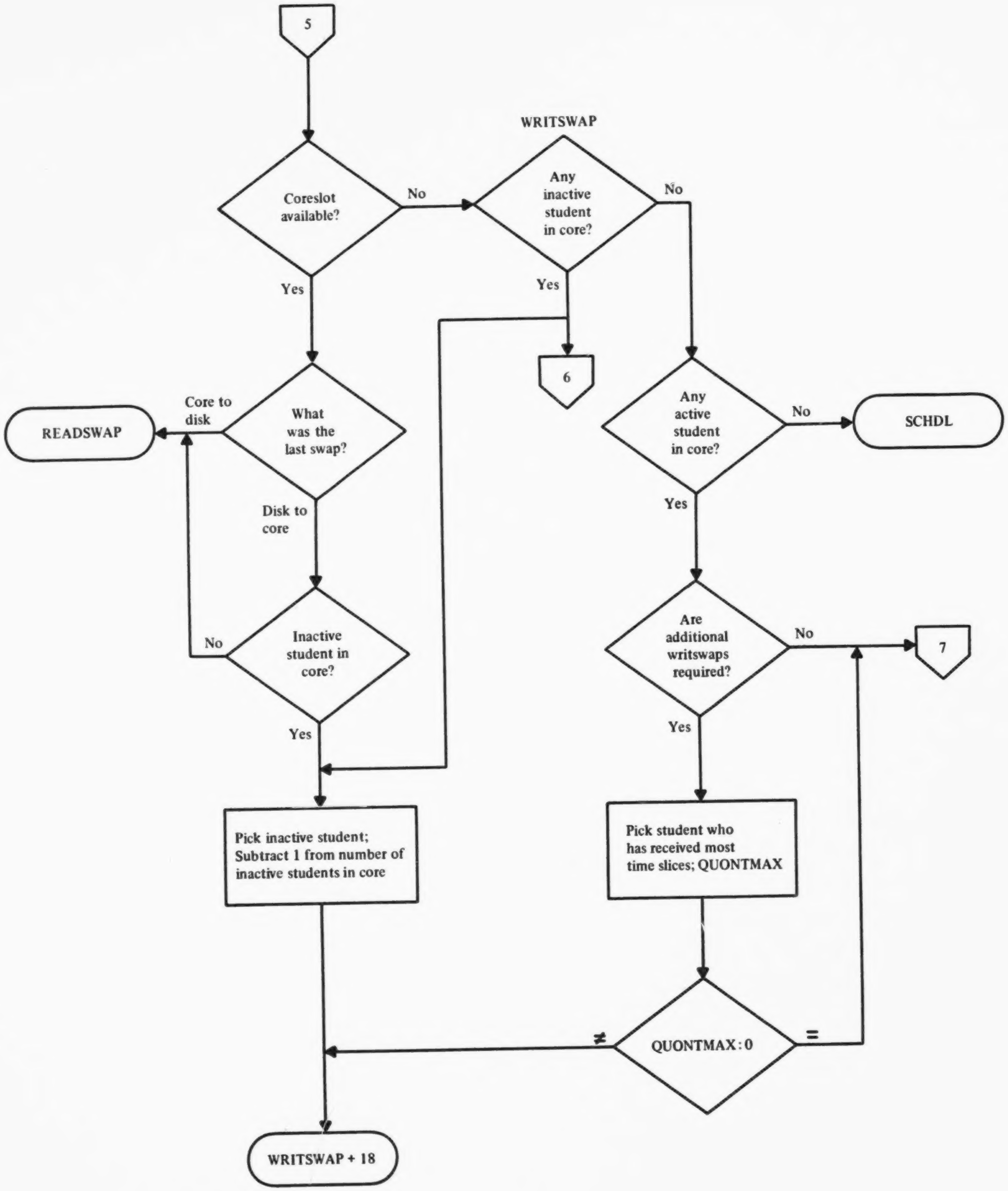
PROCESSOR INTERRUPTS (CONT'D)


2
Subtract 1 from number of readswaps in process
1
Set SELBUSY to 0
Was processor busy?
Yes
APLSCHED
No
RESCHED

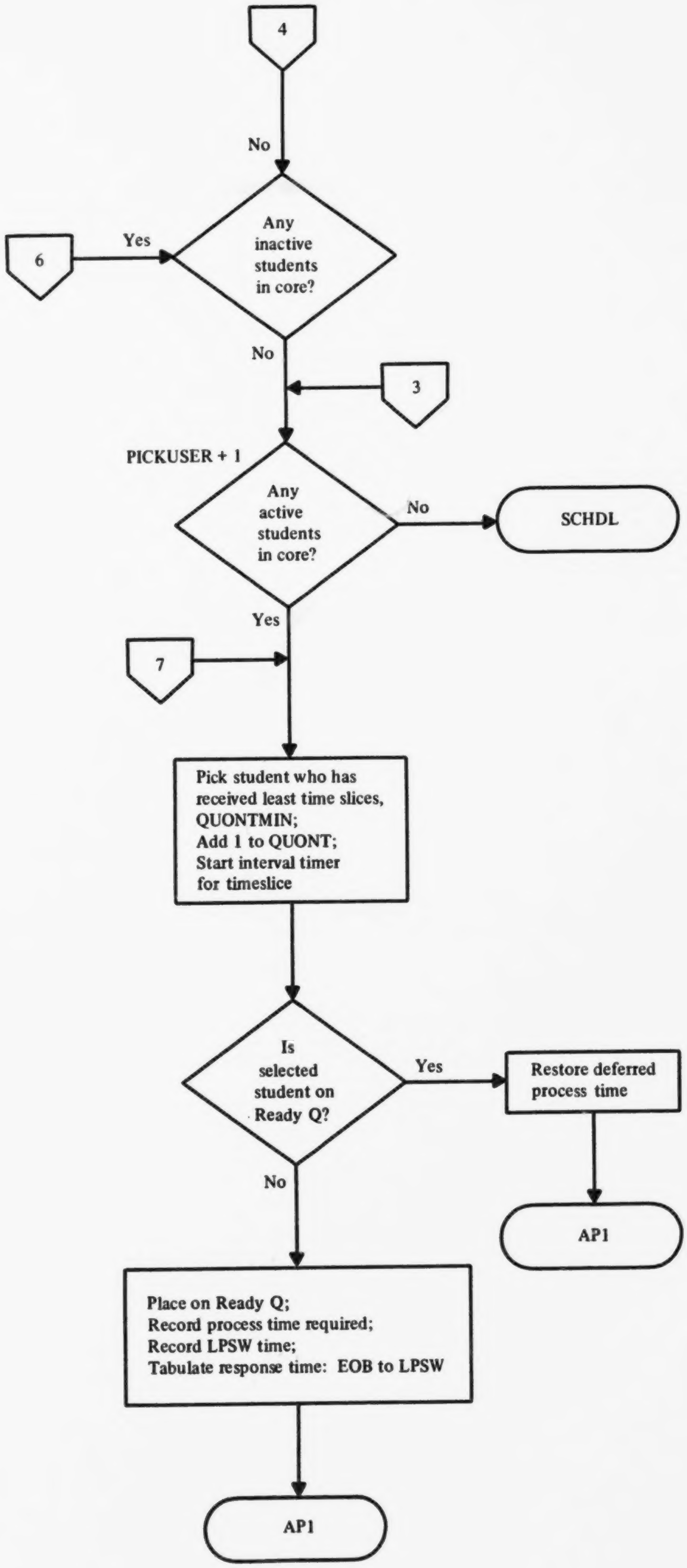
SCHEDULING ROUTINES

Problem solving scheduler:


APLSCHED
Message on Library operation Q?
Yes
Type
LIB1
LIB2
LIB3
LIB4
No
APLSCHED + 1
Any swap disk free?
No
3
Yes
Any active student on free disk?
No
4
Yes
5

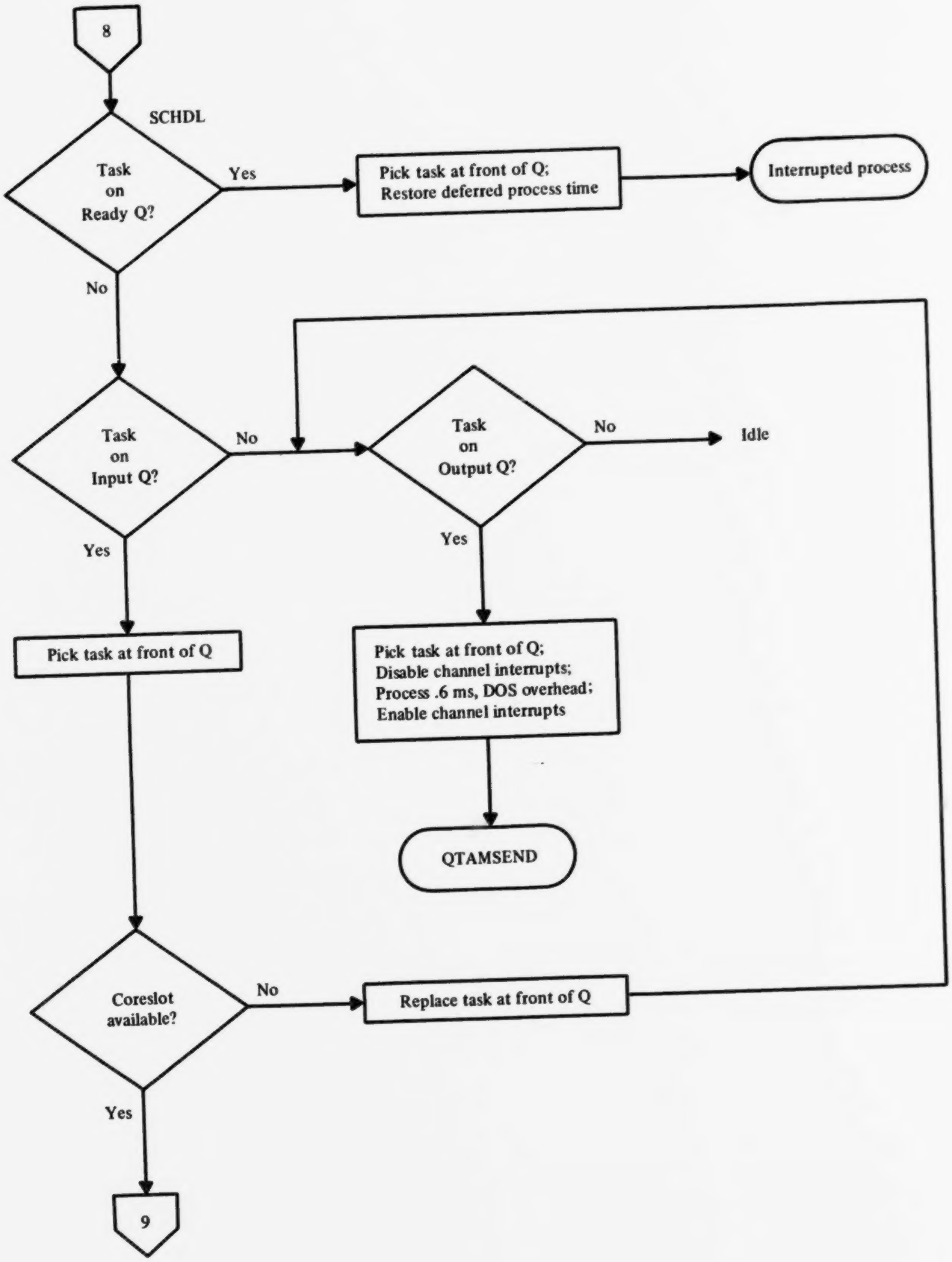

5
WRITSWAP
Coreslot available?
No
Any inactive student in core?
No
Yes
Yes
6
Core to disk
READSWAP
What was the last swap?
Any active student in core?
No
SCHDL
Disk to core
Yes
No
Inactive student in core?
Are additional writswaps required?
No
7
Yes
Yes
Pick inactive student; Subtract 1 from number of inactive students in core
Pick student who has received most time slices; QUONTMAX
≠
QUONTMAX: 0
=
WRITSWAP + 18

SCHEDULING ROUTINES (CONT'D)

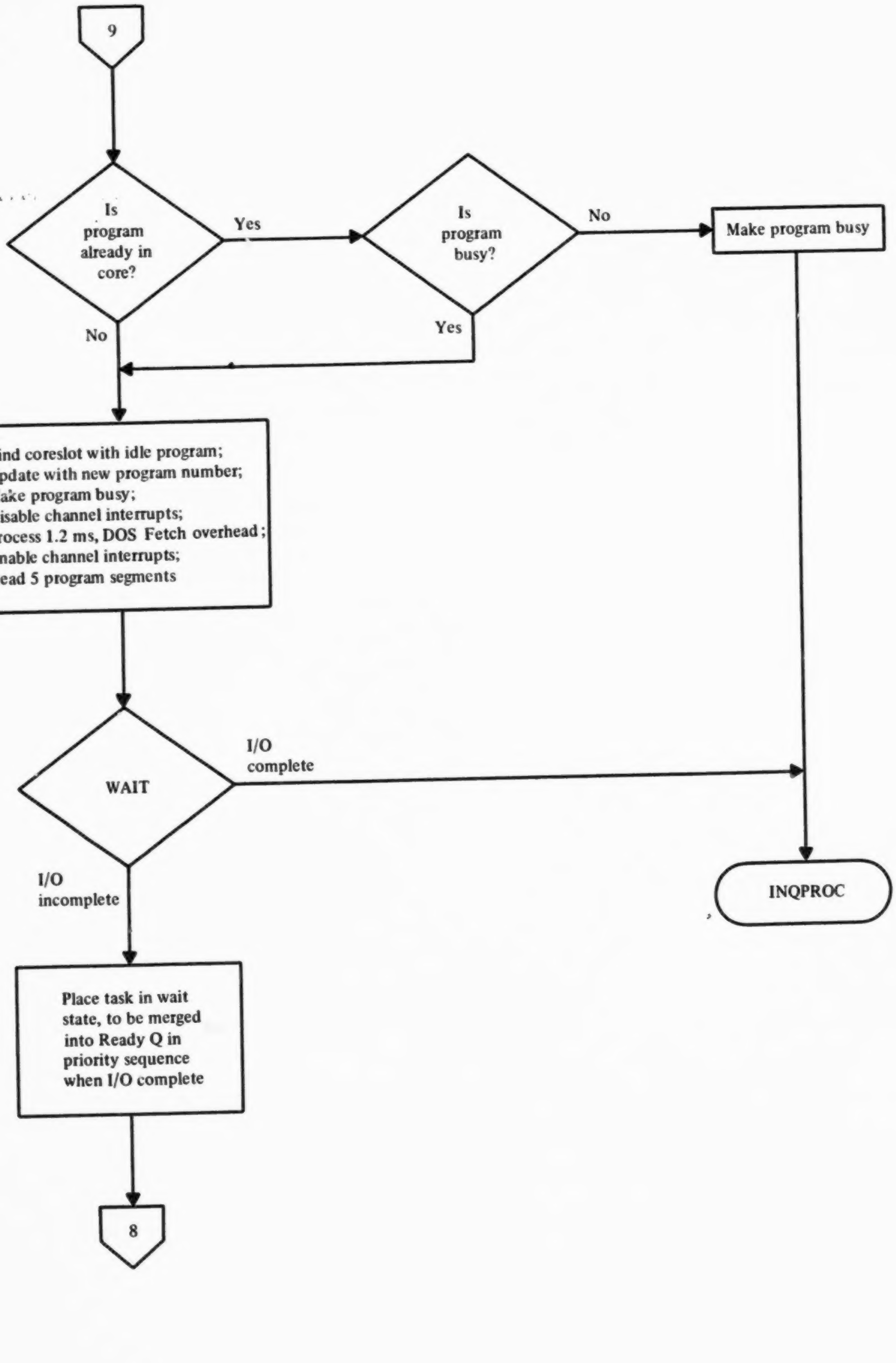

4
No
6
Yes
Any inactive students in core?
No
3
PICKUSER + 1
Any active students in core?
No
SCHDL
Yes
7
Pick student who has received least time slices, QUONTMIN; Add 1 to QUONT; Start interval timer for timeslice
Is selected student on Ready Q?
Yes
Restore deferred process time
AP1
No
Place on Ready Q; Record process time required; Record LPSW time; Tabulate response time: EOB to LPSW
AP1

SCHEDULING ROUTINES (CONT'D)

Administrative inquiry scheduler:

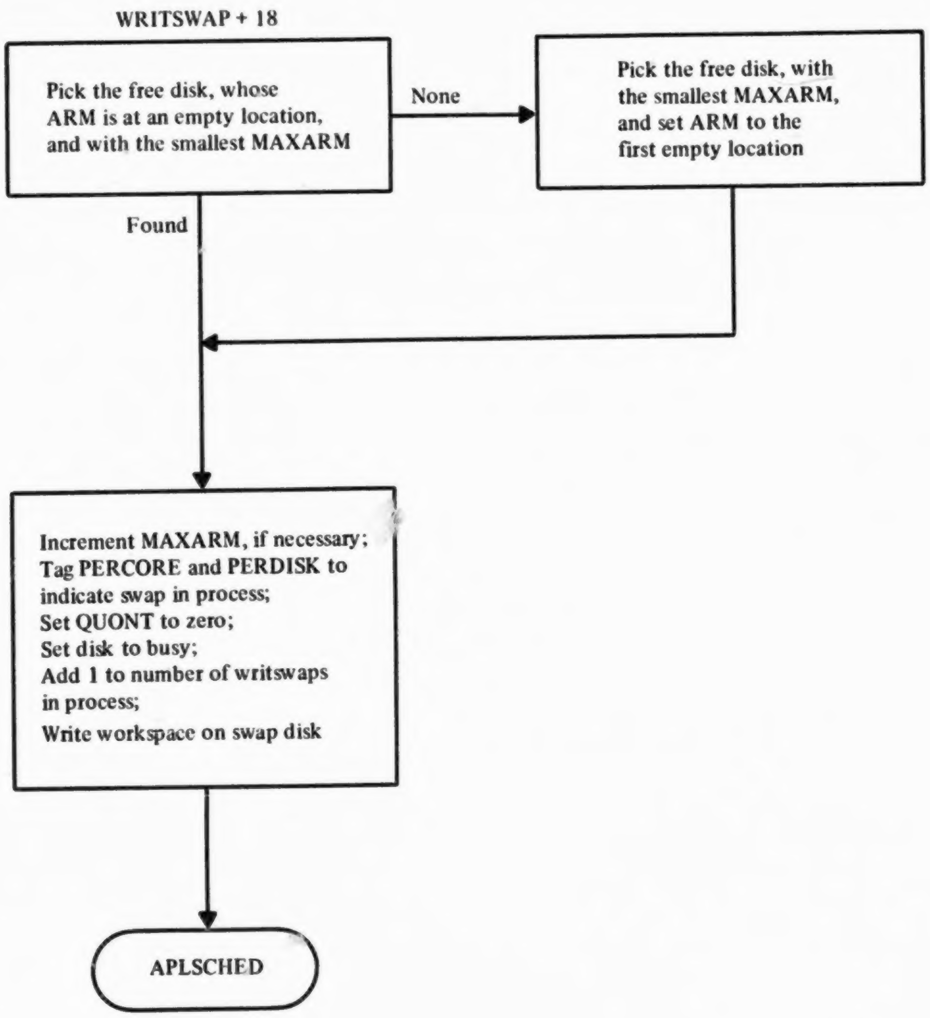

8
SCHDL
Task on Ready Q?
Yes
Pick task at front of Q; Restore deferred process time
Interrupted process
No
Task on Input Q?
No
Task on Output Q?
No
Idle
Yes
Yes
Pick task at front of Q
Pick task at front of Q; Disable channel interrupts; Process .6 ms, DOS overhead; Enable channel interrupts
QTAMSEND
Coreslot available?
No
Replace task at front of Q
Yes
9

SCHEDULING ROUTINES (CONT'D)


9
Is program already in core?
Yes
No
Is program busy?
No
Yes
Make program busy
Find coreslot with idle program;
Update with new program number;
Make program busy;
Disable channel interrupts;
Process 1.2 ms, DOS Fetch overhead;
Enable channel interrupts;
Read 5 program segments
WAIT
I/O complete
I/O incomplete
INQPROC
Place task in wait state, to be merged into Ready Q in priority sequence when I/O complete
8

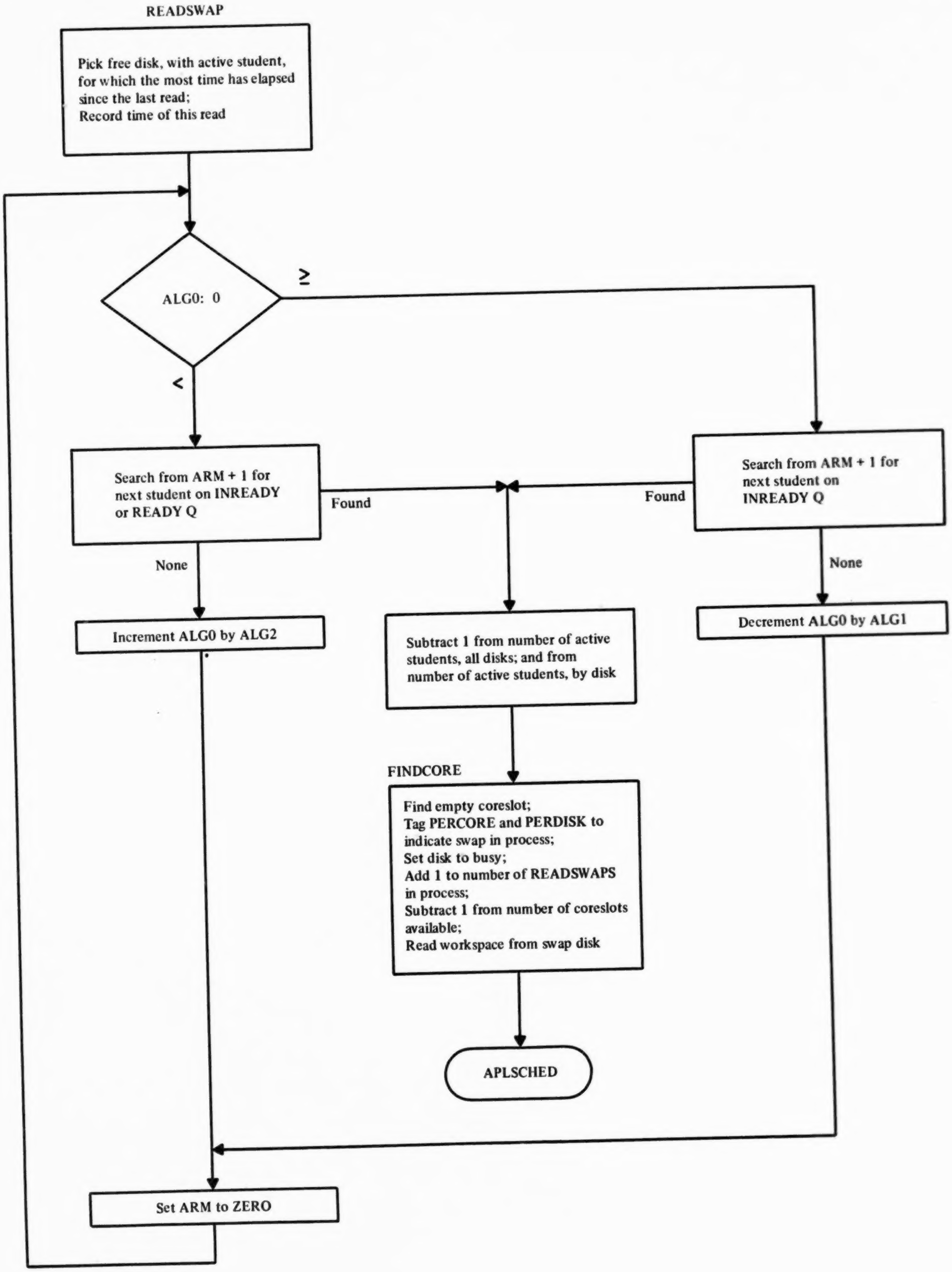
PROCESSING ROUTINES

Problem solving, swap from core to disk:


WRITSWAP + 18
Pick the free disk, whose ARM is at an empty location, and with the smallest MAXARM
None
Pick the free disk, with the smallest MAXARM, and set ARM to the first empty location
Found
Increment MAXARM, if necessary; Tag PERCORE and PERDISK to indicate swap in process; Set QUONT to zero; Set disk to busy; Add 1 to number of writswaps in process; Write workspace on swap disk
APLSCHED

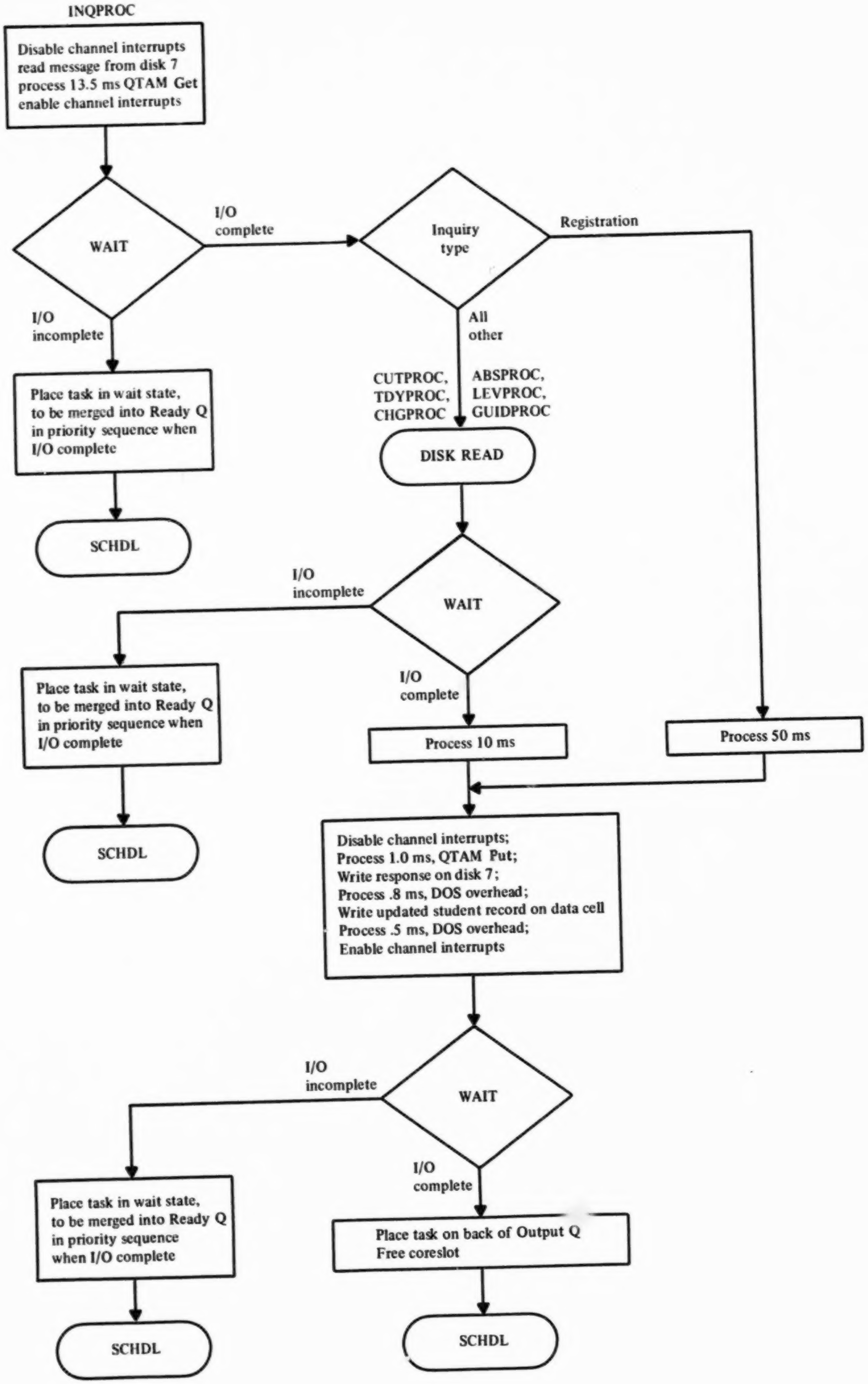
PROCESSING ROUTINES (CONT'D)

Problem solving, swap from disk to core:


READSWAP
Pick free disk, with active student, for which the most time has elapsed since the last read; Record time of this read
ALG0: 0
≥
<
Search from ARM + 1 for next student on INREADY or READY Q
Found
Search from ARM + 1 for next student on INREADY Q
Found
None
None
Increment ALG0 by ALG2
Subtract 1 from number of active students, all disks; and from number of active students, by disk
Decrement ALG0 by ALG1
FINDCORE
Find empty coreslot; Tag PERCORE and PERDISK to indicate swap in process; Set disk to busy; Add 1 to number of READSWAPS in process; Subtract 1 from number of coreslots available; Read workspace from swap disk
APLSCHED
Set ARM to ZERO

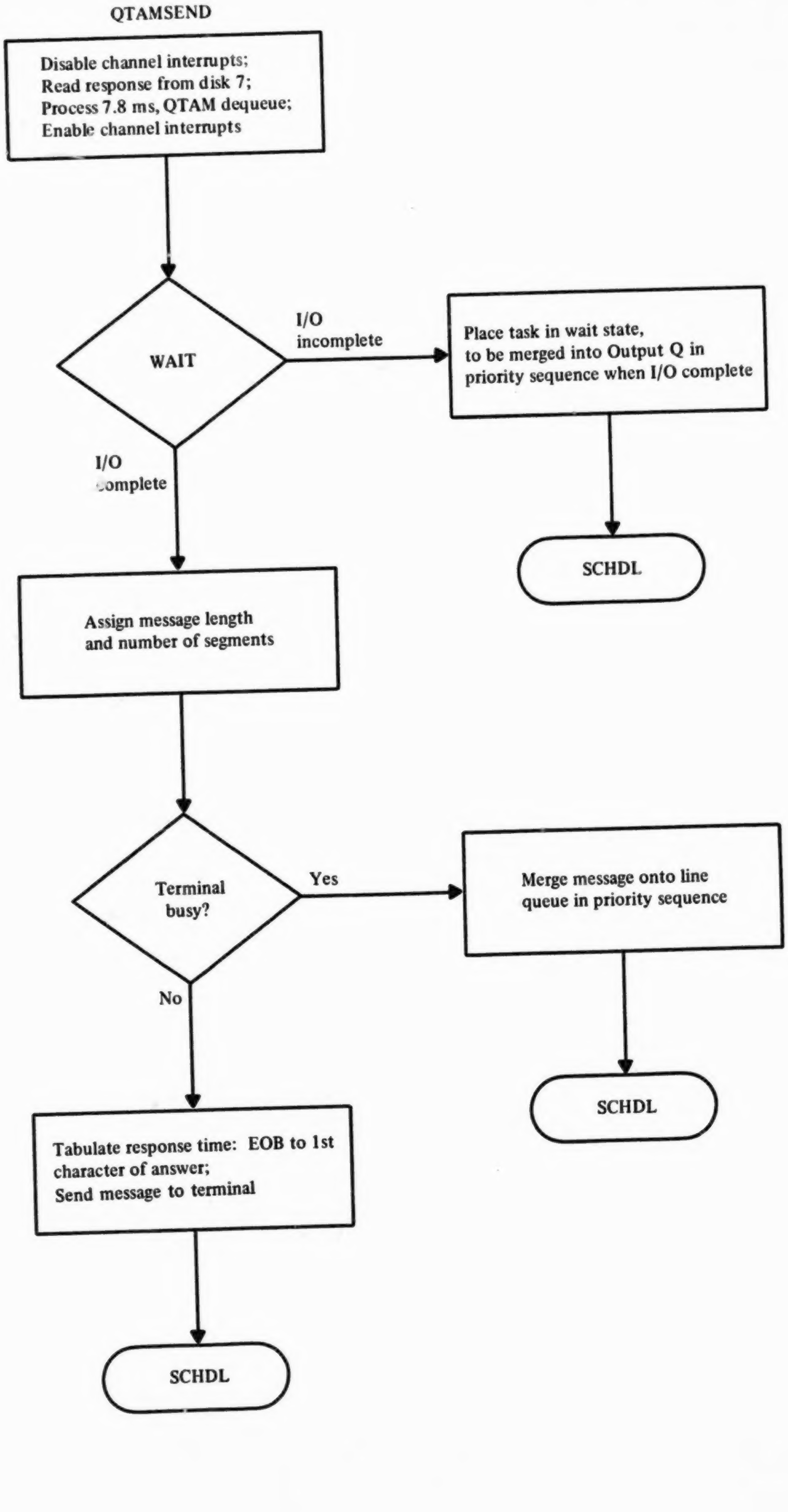
PROCESSING ROUTINES (CONT'D)

Administrative inquiry processing:


INQPROC
Disable channel interrupts read message from disk 7 process 13.5 ms QTAM Get enable channel interrupts
WAIT
I/O complete
Inquiry type
Registration
I/O incomplete
All other
CUTPROC, TDYPROC, CHGPROC
ABSPROC, LEVPROC, GUIDPROC
Place task in wait state, to be merged into Ready Q in priority sequence when I/O complete
DISK READ
SCHDL
I/O incomplete
WAIT
Place task in wait state, to be merged into Ready Q in priority sequence when I/O complete
I/O complete
Process 10 ms
Process 50 ms
SCHDL
Disable channel interrupts;
Process 1.0 ms, QTAM Put;
Write response on disk 7;
Process .8 ms, DOS overhead;
Write updated student record on data cell
Process .5 ms, DOS overhead;
Enable channel interrupts
I/O incomplete
WAIT
I/O complete
Place task in wait state, to be merged into Ready Q in priority sequence when I/O complete
Place task on back of Output Q
Free coreslot
SCHDL
SCHDL

PROCESSING ROUTINES (CONT'D)

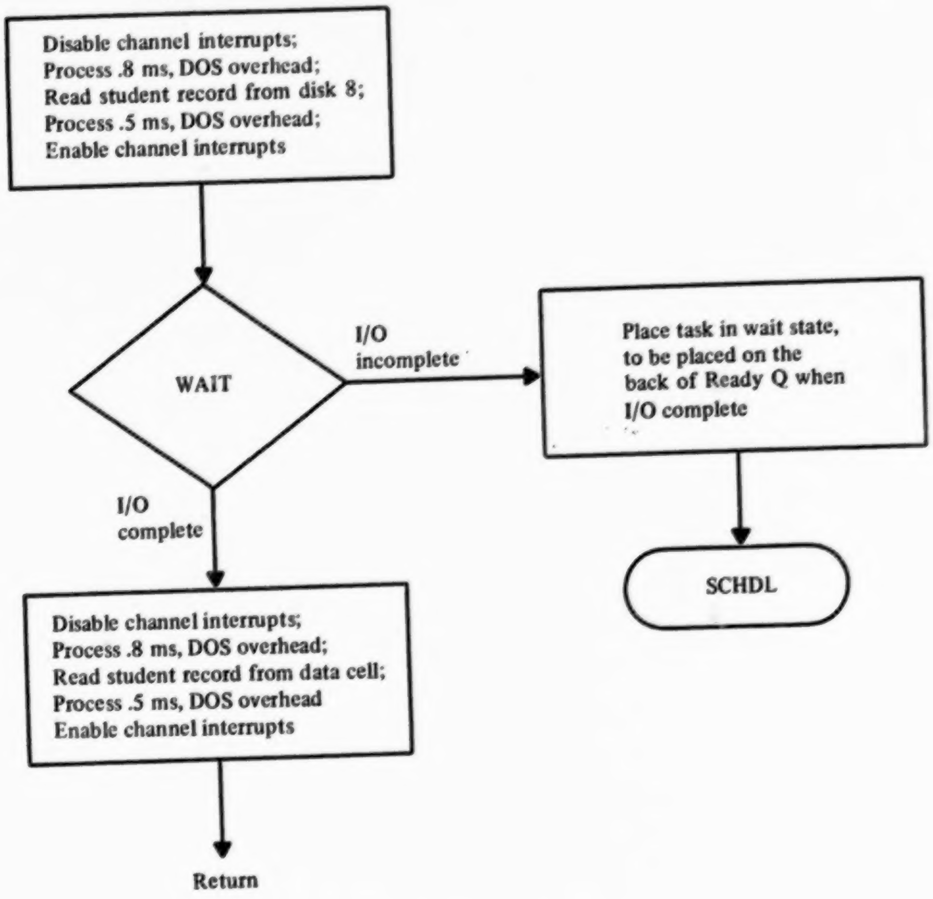
Administrative inquiry, send response to terminal:


QTAMSEND
Disable channel interrupts;
Read response from disk 7;
Process 7.8 ms, QTAM dequeue;
Enable channel interrupts
WAIT
I/O incomplete
Place task in wait state, to be merged into Output Q in priority sequence when I/O complete
SCHDL
I/O complete
Assign message length and number of segments
Terminal busy?
Yes
Merge message onto line queue in priority sequence
SCHDL
No
Tabulate response time: EOB to 1st character of answer;
Send message to terminal
SCHDL

PROCESSING ROUTINES (CONT'D)

Administrative inquiry, read student record:

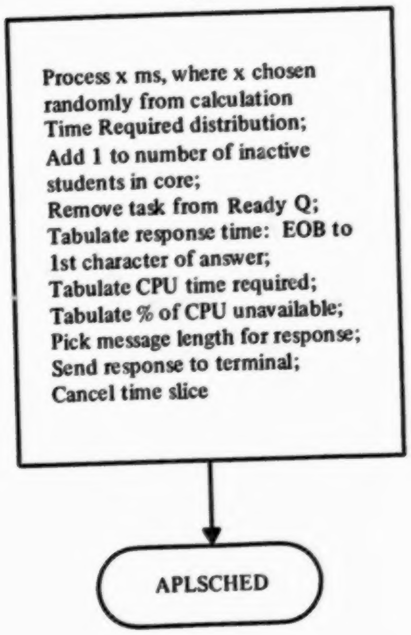
DISKREAD


Disable channel interrupts;
Process .8 ms, DOS overhead;
Read student record from disk 8;
Process .5 ms, DOS overhead;
Enable channel interrupts
WAIT
I/O incomplete
Place task in wait state, to be placed on the back of Ready Q when I/O complete
SCHDL
I/O complete
Disable channel interrupts;
Process .8 ms, DOS overhead;
Read student record from data cell;
Process .5 ms, DOS overhead
Enable channel interrupts
Return

PROCESSING ROUTINES (CONT'D)

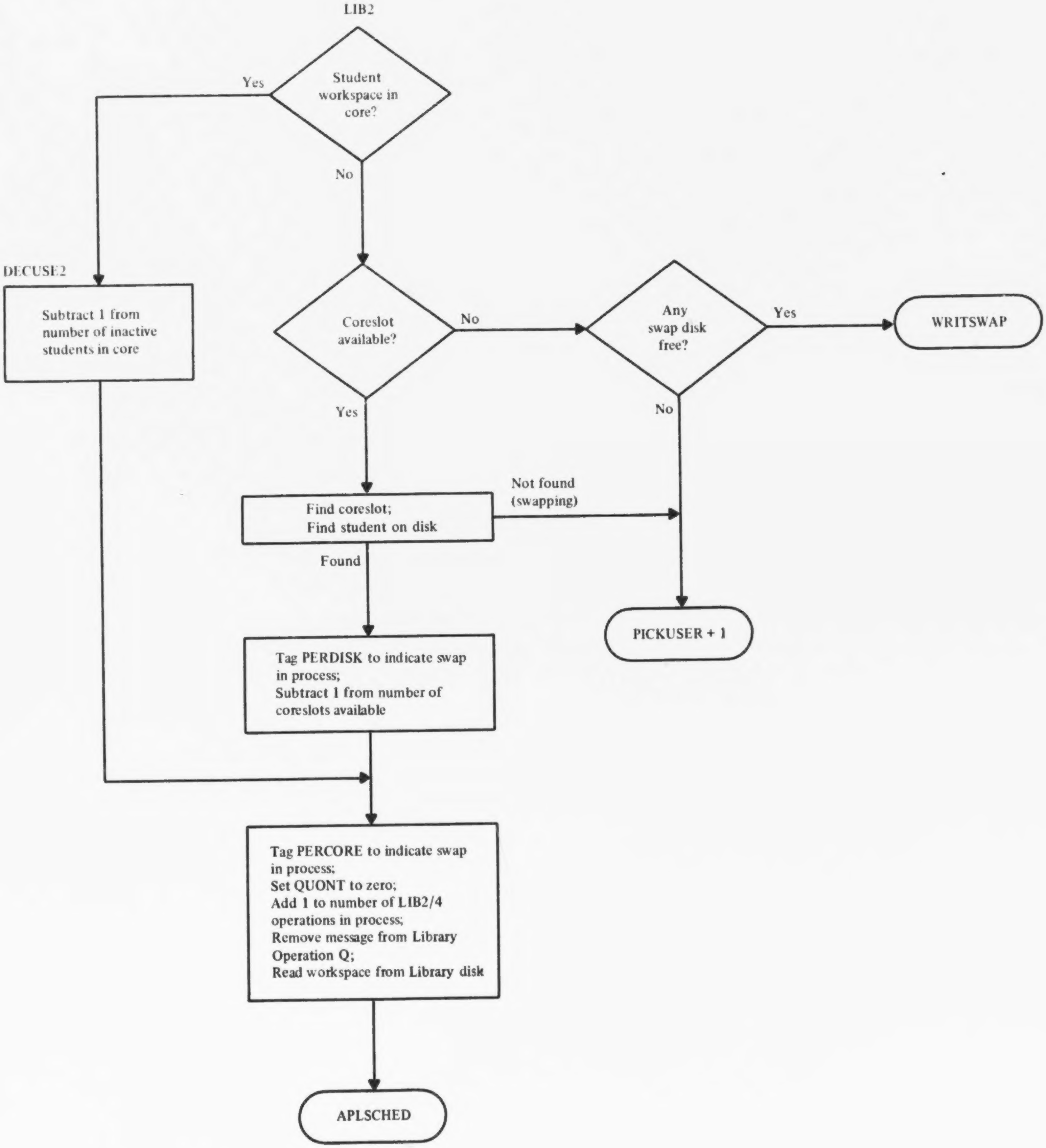
Problem solving, student request for calculation:

AP1


Process x ms, where x chosen randomly from calculation Time Required distribution;
Add 1 to number of inactive students in core;
Remove task from Ready Q;
Tabulate response time: EOB to 1st character of answer;
Tabulate CPU time required;
Tabulate % of CPU unavailable;
Pick message length for response;
Send response to terminal;
Cancel time slice
APLSCHED

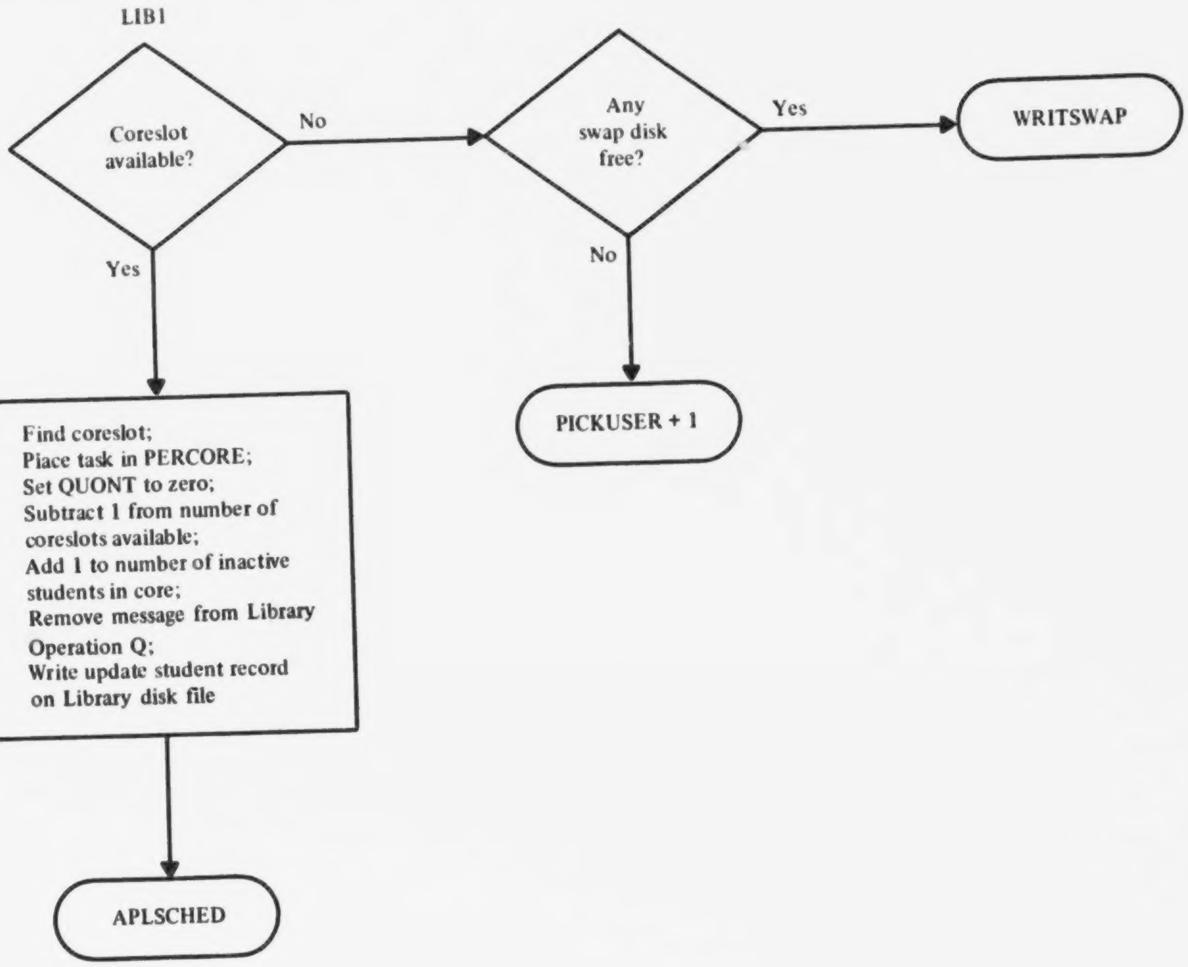
PROCESSING ROUTINES (CONT'D)

Problem solving, student request for load:

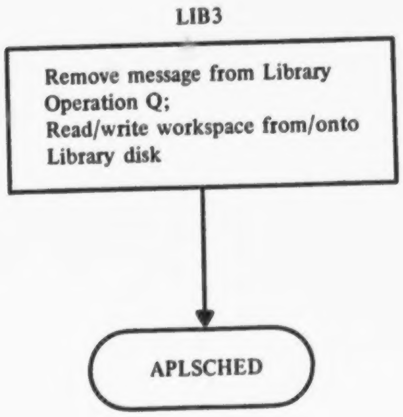

LIB2
Student workspace in core?
Yes
No
DECUSE2
Subtract 1 from number of inactive students in core
Coreslot available?
No
Yes
Any swap disk free?
Yes
No
WRITSWAP
Find coreslot;
Find student on disk
Not found (swapping)
Found
PICKUSER + 1
Tag PERDISK to indicate swap in process;
Subtract 1 from number of coreslots available
Tag PERCORE to indicate swap in process;
Set QUONT to zero;
Add 1 to number of LIB2/4 operations in process;
Remove message from Library Operation Q;
Read workspace from Library disk
APLSCHED

PROCESSING ROUTINES (CONT'D)

Problem solving, student request for sign on:

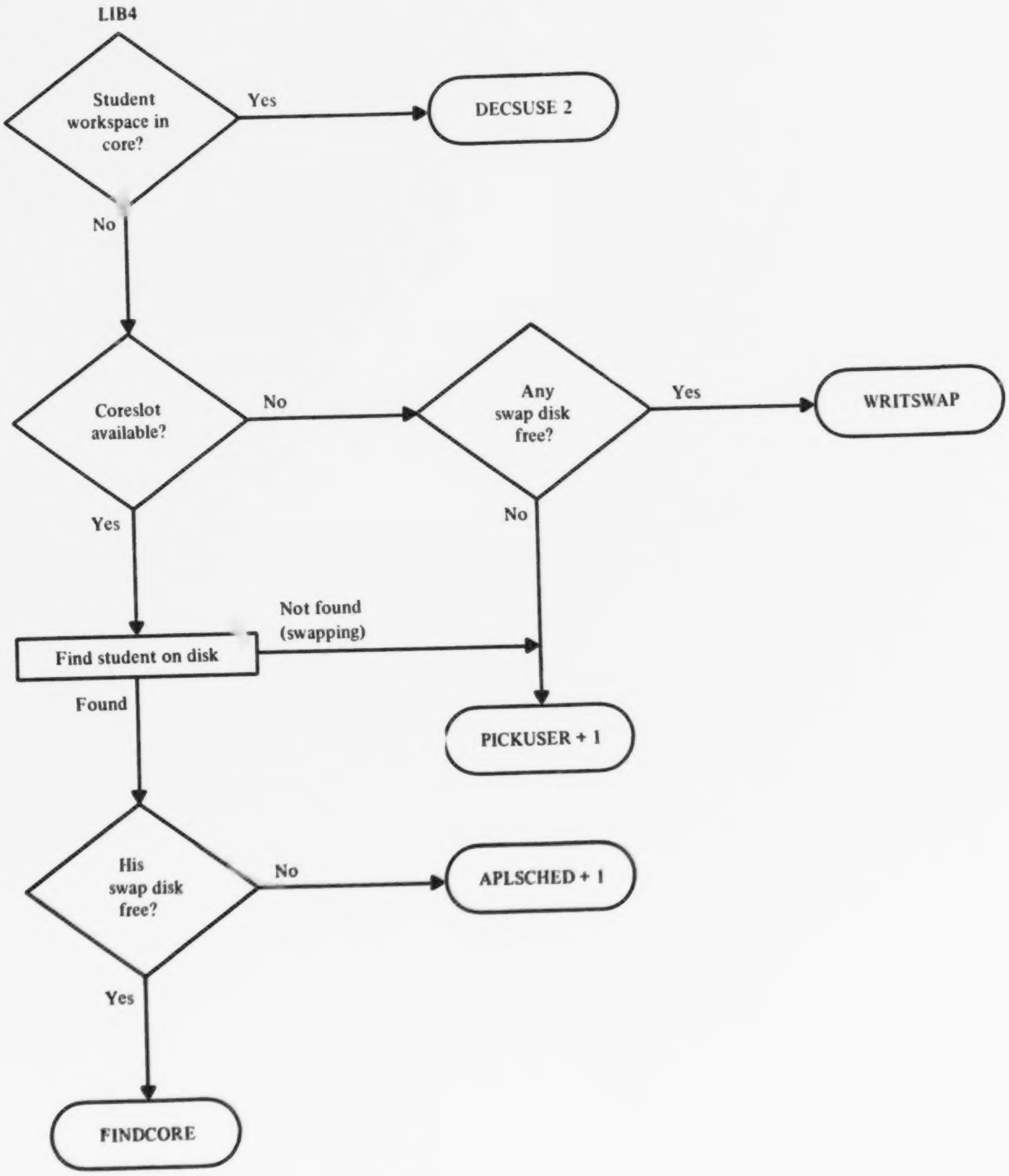

LIB1
Coreslot available?
No
Yes
Any swap disk free?
Yes
No
WRITSWAP
PICKUSER + 1
Find coreslot;
Place task in PERCORE;
Set QUONT to zero;
Subtract 1 from number of coreslots available;
Add 1 to number of inactive students in core;
Remove message from Library Operation Q;
Write update student record on Library disk file
APLSCHED

Problem solving, student request for drop, add, or lib:


LIB3
Remove message from Library Operation Q;
Read/write workspace from/onto Library disk
APLSCHED

PROCESSING ROUTINES (CONT'D)

Problem solving, student request for save, off, or copy:


LIB4
Student workspace in core?
Yes
DECSUSE 2
No
Coreslot available?
No
Any swap disk free?
Yes
WRITSWAP
No
Yes
Find student on disk
Not found (swapping)
Found
PICKUSER + 1
His swap disk free?
No
APLSCHED + 1
Yes
FINDCORE

Addendum 11

Sample Simulator Results

This section contains samples of some of the more significant simulator output obtained for the USOE Model Region. These are described below.

1. Processor Information	Includes processor utilization
2. Channel Statistics	Where channels 1-167 are multiple. Subchannels used for instructional terminals, channels 226-277 are multiplexer subchannels used for administrative terminals and channel 302 is the selector channel. Utilization of the multiplexer subchannels is computed on the basis of a 14.7-character-per-second transmission rate, which is not true for information transmitted from a keyboard.
3. I/O Device Statistics	Device Type Device is a dummy device used to model the time-slicing interval timer. Device Type 2311 is actually a 2314 and for modeling simplicity drive number 1 shows all Reads whereas in the actual system a portion of these READS would be WRITES.
4. Distribution Tables 1,2,3, 4,8	Various administrative inquiry response times, as indicated. Time unit is .1 ms.
5. Distribution Table 11	Problem-solving response time, from the end of the student request until the first channel of the answer begins to type. Time unit is .1 ms.
6. Distribution Table 12	Problem-solving response time, from the end of the student request until the beginning of the first timeslice received. Time unit is .1 ms.
7. Distribution Table 13	Problem-solving Calculation Time Required. The mean of the parent distribution is .25 sec. The time unit is .1 ms. There are fewer entries in this table than in Distribution Table because the minimal CPU time for library operations was not modeled.
8. Distribution Table 14	Problem-solving percentage of CPU which appears to be unavailable after the beginning of first timeslice received. The 1st entry in the table shows that for 6.5% of the requests the CPU was 0% unavailable (100% available) the 19th entry shows that for 50.1% of the request the CPU was 18% or less unavailable (82% or more available), and so forth.

```
                              *******************************
                              *                             *
                              *   PROCESSOR   INFORMATION   *
                              *                             *
                              *******************************

PROCESSOR NUMBER    0, CURRENTLY IDLE, REPRESENTS THE SYSTEM ENVIRONMENT.

                    TOTAL PROCESSOR UTILIZATION                      .0000

                    UTILIZATION DUE TO CHANNEL INTERFERENCE          .0000

                    INTERVAL TIMER CURRENTLY  ENABLED

                    THE CURRENT VALUES OF THE PROCESSOR ATTRIBUTES ARE

                      CIR          CMES          CTASK          CCOM

                      20            333           334

                      RIR          RMES          RTASK          RCOM          RNOTE

                      20             3

PROCESSOR NUMBER    1  CURRENTLY IDLE

                    TOTAL PROCESSOR UTILIZATION                      .7954

                    UTILIZATION DUE TO CHANNEL INTERFERENCE          .0321

                    INTERVAL TIMER CURRENTLY  ENABLED

                    THE CURRENT VALUES OF THE PROCESSOR ATTRIBUTES ARE

                      CIR          CMES          CTASK          CCOM

                      671           552           404           583

                      RIR          RMES          RTASK          RCOM          RNOTE

                      671           251

                              ***************************
                              *                         *
                              *   CHANNEL   STATISTICS  *
                              *                         *
                              ***************************

CHANNEL         TYPE          UTILIZATION       TOTAL READS       TOTAL WRITES        STATUS

   1            M  1             .0274               57                57              IDLE
   2            M  1             .0249               53                53              IDLE
   3            M  1             .0387               73                73              IDLE
   4            M  1             .0315               63                63              IDLE
   5            M  1             .0347               63                63              IDLE
   6            M  1             .0283               53                53              IDLE
   7            M  1             .0481               84                84              IDLE
   8            M  1             .0331               69                69              IDLE
   9            M  1             .0275               61                61              IDLE
  10            M  1             .0372               69                69              IDLE
  11            M  1             .0319               59                59              IDLE
  12            M  1             .0194               52                52              IDLE
  13            M  1             .0372               67                67              IDLE
  14            M  1             .0326               64                64              IDLE
  15            M  1             .0381               75                75              IDLE
  16            M  1             .0283               59                59              IDLE
  17            M  1             .0284               58                58              IDLE
  18            M  1             .0280               53                53              IDLE
  19            M  1             .0232               49                49              IDLE
  20            M  1             .0321               63                63              IDLE
  21            M  1             .0408               90                89              IDLE
  22            M  1             .0373               79                80              IDLE
  23            M  1             .0236               46                46              IDLE
  24            M  1             .0296               58                58              IDLE
  25            M  1             .0413               68                68              IDLE
```

```
26     M  1     .0230     57     57     IDLE
27     M  1     .0276     60     61     IDLE
28     M  1     .0228     49     49     IDLE
29     M  1     .0279     49     49     IDLE
30     M  1     .0342     67     67     IDLE
31     M  1     .0303     60     60     IDLE
32     M  1     .0300     59     59     IDLE
33     M  1     .0265     64     64     IDLE
34     M  1     .0346     67     67     IDLE
35     M  1     .0250     65     65     IDLE
36     M  1     .0297     60     60     IDLE
37     M  1     .0293     51     51     IDLE
38     M  1     .0304     59     59     IDLE
39     M  1     .0436     78     78     IDLE
40     M  1     .0340     71     71     IDLE
41     M  1     .0372     69     69     IDLE
42     M  1     .0296     64     64     IDLE
43     M  1     .0247     52     52     IDLE
44     M  1     .0288     57     57     IDLE
45     M  1     .0339     66     66     IDLE
46     M  1     .0202     45     45     IDLE

47     M  1     .0352     64     64     IDLE
48     M  1     .0233     52     52     IDLE
49     M  1     .0368     69     69     IDLE
50     M  1     .0323     70     70     IDLE
51     M  1     .0259     59     59     IDLE
52     M  1     .0366     74     74     IDLE
53     M  1     .0326     61     61     IDLE
54     M  1     .0250     50     50     IDLE
55     M  1     .0291     62     62     IDLE
56     M  1     .0241     50     50     IDLE
57     M  1     .0239     45     45     IDLE
58     M  1     .0374     69     69     IDLE
59     M  1     .0228     43     43     IDLE
60     M  1     .0289     70     70     IDLE
61     M  1     .0370     64     64     IDLE
62     M  1     .0264     56     56     IDLE
63     M  1     .0273     58     58     IDLE
64     M  1     .0269     50     50     IDLE
65     M  1     .0308     56     56     IDLE
66     M  1     .0221     44     45     IDLE
67     M  1     .0406     75     75     IDLE
68     M  1     .0391     70     70     IDLE
69     M  1     .0265     42     42     IDLE
70     M  1     .0239     62     62     IDLE
71     M  1     .0317     64     64     IDLE
72     M  1     .0390     69     69     IDLE
73     M  1     .0449     81     81     IDLE
74     M  1     .0483     77     77     IDLE
75     M  1     .0390     72     72     IDLE
76     M  1     .0331     69     69     IDLE
77     M  1     .0236     46     46     IDLE
78     M  1     .0345     60     60     IDLE
79     M  1     .0260     68     68     IDLE
80     M  1     .0269     61     61     IDLE
81     M  1     .0396     59     59     IDLE
82     M  1     .0234     48     48     IDLE
83     M  1     .0395     69     69     IDLE
84     M  1     .0299     64     64     IDLE
85     M  1     .0310     66     66     IDLE
86     M  1     .0196     38     38     IDLE
87     M  1     .0396     77     77     IDLE
88     M  1     .0266     56     56     IDLE
89     M  1     .0353     57     57     IDLE
90     M  1     .0278     53     53     IDLE
91     M  1     .0284     63     62     IDLE
92     M  1     .0319     63     63     IDLE
93     M  1     .0272     60     60     IDLE
94     M  1     .0242     47     47     IDLE
95     M  1     .0188     42     42     IDLE
96     M  1     .0277     68     68     IDLE
97     M  1     .0216     41     41     IDLE
98     M  1     .0309     69     69     IDLE
99     M  1     .0302     63     63     IDLE
```

```
100    M  1    .0333    71    71    IDLE
101    M  1    .0233    44    44    IDLE
102    M  1    .0204    48    48    IDLE
103    M  1    .0198    36    36    IDLE
104    M  1    .0329    68    68    IDLE
105    M  1    .0346    69    69    IDLE
106    M  1    .0196    54    54    IDLE
107    M  1    .0301    61    61    IDLE
108    M  1    .0309    62    62    IDLE
109    M       .0180    40    40    IDLE
110    M  1    .0310    69    69    IDLE
111    M  1    .0309    59    59    IDLE
112    M  1    .0299    51    51    IDLE
113    M  1    .0259    52    52    IDLE
114    M  1    .0310    59    59    IDLE
115    M  1    .0217    48    48    IDLE
116    M  1    .0349    75    75    IDLE
117    M  1    .0271    56    56    IDLE
118    M  1    .0277    55    55    IDLE
119    M  1    .0275    56    56    IDLE
120    M  1    .0331    62    62    IDLE
121    M  1    .0192    42    42    IDLE
122    M  1    .0350    78    78    IDLE
123    M  1    .0261    63    63    IDLE
124    M  1    .0197    44    44    IDLE
125    M  1    .0300    49    49    IDLE
126    M  1    .0397    81    81    IDLE
127    M  1    .0401    74    74    IDLE
128    M  1    .0407    79    79    IDLE
129    M  1    .0303    56    56    IDLE
130    M  1    .0310    61    61    IDLE
131    M  1    .0195    49    49    IDLE
132    M  1    .0328    53    53    IDLE
133    M  1    .0346    64    64    IDLE
134    M  1    .0220    59    59    IDLE
135    M  1    .0319    62    62    IDLE
136    M  1    .0376    71    71    IDLE
137    M  1    .0272    56    56    IDLE
138    M  1    .0322    60    60    IDLE
139    M  1    .0216    47    47    IDLE
140    M  1    .0337    66    66    IDLE
141    M  1    .0338    65    65    IDLE
142    M  1    .0282    55    55    IDLE
143    M  1    .0336    69    69    IDLE
144    M  1    .0375    63    63    IDLE
145    M  1    .0319    71    71    IDLE
146    M  1    .0220    46    46    IDLE
147    M  1    .0230    51    51    IDLE
148    M  1    .0331    68    68    IDLE
149    M  1    .0399    79    79    IDLE
150    M  1    .0285    47    47    IDLE
151    M  1    .0338    68    68    IDLE
152    M  1    .0356    74    74    IDLE
153    M  1    .0332    64    64    IDLE
154    M  1    .0242    52    52    IDLE
155    M  1    .0335    64    64    IDLE
156    M  1    .0345    70    70    IDLE
157    M  1    .0207    43    43    IDLE
158    M  1    .0273    60    60    IDLE
159    M  1    .0291    53    53    IDLE
160    M  1    .0215    48    48    IDLE
161    M  1    .0276    60    60    IDLE
162    M  1    .0250    60    60    IDLE
163    M  1    .0281    68    68    IDLE
164    M  1    .0309    62    61    BUSY
165    M  1    .0302    59    59    IDLE
166    M  1    .0247    51    51    BUSY
167    M  1    .0234    47    47    IDLE
168    M  1    .0000     0     0    IDLE
169    M  1    .0000     0     0    IDLE
170    M  1    .0000     0     0    IDLE
171    M  1    .0000     0     0    IDLE
172    M  1    .0000     0     0    IDLE
173    M  1    .0000     0     0    IDLE
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174    M  1    .0000     0     0    IDLE
175    M  1    .0000     0     0    IDLE
176    M  1    .0000     0     0    IDLE
177    M  1    .0000     0     0    IDLE
178    M  1    .0000     0     0    IDLE
179    M  1    .0000     0     0    IDLE
180    M  1    .0000     0     0    IDLE
181    M  1    .0000     0     0    IDLE
182    M  1    .0000     0     0    IDLE
183    M  1    .0000     0     0    IDLE
184    M  1    .0000     0     0    IDLE
185    M  1    .0000     0     0    IDLE
186    M  1    .0000     0     0    IDLE
187    M  1    .0000     0     0    IDLE
188    M  1    .0000     0     0    IDLE
189    M  1    .0000     0     0    IDLE
190    M  1    .0000     0     0    IDLE
191    M  1    .0000     0     0    IDLE
192    M  1    .0000     0     0    IDLE
193    M  1    .0000     0     0    IDLE
194    M  1    .0000     0     0    IDLE
195    M  1    .0000     0     0    IDLE
196    M  1    .0000     0     0    IDLE
197    M  1    .0000     0     0    IDLE
198    M  1    .0000     0     0    IDLE
199    M  1    .0000     0     0    IDLE
200    M  1    .0000     0     0    IDLE
201    M  1    .0000     0     0    IDLE
202    M  1    .0000     0     0    IDLE
203    M  1    .0000     0     0    IDLE
204    M  1    .0000     0     0    IDLE
205    M  1    .0000     0     0    IDLE
206    M  1    .0000     0     0    IDLE
207    M  1    .0000     0     0    IDLE
208    M  1    .0000     0     0    IDLE
209    M  1    .0000     0     0    IDLE
210    M  1    .0000     0     0    IDLE
211    M  1    .0000     0     0    IDLE
212    M  1    .0000     0     0    IDLE
213    M  1    .0000     0     0    IDLE
214    M  1    .0000     0     0    IDLE
215    M  1    .0000     0     0    IDLE
216    M  1    .0000     0     0    IDLE
217    M  1    .0000     0     0    IDLE
218    M  1    .0000     0     0    IDLE
219    M  1    .0000     0     0    IDLE
220    M  1    .0000     0     0    IDLE
221    M  1    .0000     0     0    IDLE
222    M  1    .0000     0     0    IDLE
223    M  1    .0000     0     0    IDLE
224    M  1    .0000     0     0    IDLE
225    M  1    .0000     0     0    IDLE
226    M  1    .2324    51    52    IDLE
227    M  1    .0628    51    33    BUSY
228    M  1    .0650    40    29    BUSY
229    M  1    .1626    62    47    IDLE
230    M  1    .1155    43    38    BUSY
231    M  1    .1252    58    47    BUSY
232    M  1    .1266    54    41    BUSY
233    M  1    .0909    42    32    BUSY
234    M  1    .2489    44    42    BUSY
235    M  1    .0354    40    24    IDLE
236    M  1    .1569    43    47    BUSY
237    M  1    .0995    38    27    BUSY
238    M  1    .1327    42    40    BUSY
239    M  1    .0841    45    39    IDLE
240    M  1    .1075    53    35    BUSY
241    M  1    .1649    52    51    BUSY
242    M  1    .1110    41    35    BUSY
243    M  1    .1031    41    38    BUSY
244    M  1    .1902    55    43    BUSY
245    M  1    .1901    46    41    BUSY
246    M  1    .0378    43    31    IDLE
247    M  1    .1992    56    59    IDLE
248    M  1    .0413    38    36    BUSY
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   249            M  1          .0977           41            33           BUSY
   250            M  1          .1001           46            36           BUSY
   251            M  1          .1244           61            43           BUSY
   252            M  1          .2123           48            46           BUSY
   253            M  1          .0542           38            34           BUSY
   254            M  1          .0488           40            29           BUSY
   255            M  1          .0925           46            37           BUSY
   256            M  1          .2204           56            55           BUSY
   257            M  1          .1720           48            46           BUSY
   258            M  1          .1405           54            38           BUSY
   259            M  1          .1435           41            37           BUSY
   260            M  1          .1084           41            36           BUSY
   261            M  1          .1581           43            39           BUSY
   262            M  1          .2452           64            63           BUSY
   263            M  1          .2190           59            56           BUSY
   264            M  1          .1038           39            39           BUSY
   265            M  1          .1322           56            42           BUSY
   266            M  1          .1177           37            35           BUSY
   267            M  1          .1402           36            38           BUSY
   268            M  1          .1838           37            43           BUSY
   269            M  1          .1916           57            49           BUSY
   270            M  1          .2214           58            48           BUSY
   271            M  1          .2442           69            52           BUSY
   272            M  1          .2219           45            48           BUSY
   273            M  1          .0546           35            31           BUSY
   274            M  1          .1157           41            38           BUSY
   275            M  1          .2078           48            48           BUSY
   276            M  1          .0000            0             0           IDLE
   277            M  1          .0000            0             0           IDLE
   278            M  1          .0000            0             0           IDLE
   279            M  1          .0000            0             0           IDLE
   280            M  1          .0000            0             0           IDLE
   281            M  1          .0000            0             0           IDLE
   282            M  1          .0000            0             0           IDLE
   283            M  1          .0000            0             0           IDLE
   284            M  1          .0000            0             0           IDLE
   285            M  1          .0000            0             0           IDLE
   286            M  1          .0000            0             0           IDLE
   287            M  1          .0000            0             0           IDLE
   288            M  1          .0000            0             0           IDLE
   289            M  1          .0000            0             0           IDLE
   290            M  1          .0000            0             0           IDLE
   291            M  1          .0000            0             0           IDLE
   292            M  1          .0000            0             0           IDLE
   293            M  1          .0000            0             0           IDLE
   294            M  1          .0000            0             0           IDLE
   295            M  1          .0000            0             0           IDLE
   296            M  1          .0000            0             0           IDLE
   297            M  1          .0000            0             0           IDLE
   298            M  1          .0000            0             0           IDLE
   299            M  1          .0000            0             0           IDLE
   300            M  1          .0000            0             0           IDLE
   301            S             .0000            0             0           IDLE
   302            S             .3955        19589         17640           BUSY

                          ****************************
                          *                          *
                          *  I/O  DEVICE  STATISTICS *
                          *                          *
                          ****************************

DEVICE TYPE       NUMBER       UTILIZATION     TOTAL READS    TOTAL WRITES      STATUS

  DEVICE            1            .7614               0              0           IDLE

  2311              1            .0208             608              0           IDLE
                    2            .0990            2333           2402           IDLE
                    3            .1007            2365           2432           IDLE
                    4            .1077            2564           2625           BUSY
                    5            .1039            2493           2556           IDLE
                    6            .0637            3976              0           BUSY
                    7            .0748            1754           4117           IDLE
                    8            .0784            1750           1755           IDLE

  2321              1            .4630            1746           1753           BUSY
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                                        *                        *
                                        *  DISTRIBUTION  TABLES  *
                                        *                        *
                                        **************************



                                              *  DISTL     1  *


WAIT TIME UNTIL TERMINAL AVAILABLE -- 1050 ONLY

     ENTRIES IN TABLE          MEAN ARGUMENT          STANDARD DEVIATION

             1906                 83405.278                  433408.030

              UPPER              OBSERVED             PERCENT          CUMULATIVE           CUMULATIVE
              LIMIT              FREQUENCY            OF TOTAL         PERCENTAGE            REMAINDER

                  0                 1718               90.136                90.1                  9.8
             600000                  105                5.508                95.6                  4.3
            1200000                   32                1.678                97.3                  2.6
            1800000                   27                1.416                98.7                  1.2
            2400000                    5                0.262                99.0                  0.9
            3000000                    1                0.052                99.0                  0.9
            3600000                   12                0.629                99.6                  0.3
            4200000                    1                0.052                99.7                  0.2
            4800000                    3                0.157                99.8                  0.1
            5400000                    2                0.104               100.0                  0.0

     REMAINING FREQUENCIES ARE ALL ZERO

                                              *  DISTL     2  *


CUT INQUIRY RESPONSE TIME  EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

     ENTRIES IN TABLE          MEAN ARGUMENT          STANDARD DEVIATION

              344                983808.691                  640256.016

              UPPER              OBSERVED             PERCENT          CUMULATIVE           CUMULATIVE
              LIMIT              FREQUENCY            OF TOTAL         PERCENTAGE            REMAINDER

                  0                    0                0.000                 0.0                100.0
              60000                    0                0.000                 0.0                100.0
             120000                   11                3.197                 3.1                 96.8
             180000                   12                3.488                 6.6                 93.3
             240000                   12                3.488                10.1                 89.8
             300000                   12                3.488                13.6                 86.3
             360000                   14                4.069                17.7                 82.2
             420000                   17                4.941                22.6                 77.3
             480000                   15                4.360                27.0                 72.9
             540000                   10                2.906                29.9                 70.0
             600000                    9                2.616                32.5                 67.4
             660000                   12                3.488                36.0                 63.9
             720000                   25                7.267                43.3                 56.6
             780000                   13                3.779                47.0                 52.9
             840000                   11                3.197                50.2                 49.7
             900000                   13                3.779                54.0                 45.9
             960000                    8                2.325                56.3                 43.6
            1020000                    5                1.453                57.8                 42.1
            1080000                    5                1.453                59.3                 40.6
            1140000                    8                2.325                61.6                 38.3
            1200000                   10                2.906                64.5                 35.4
            1260000                    8                2.325                66.8                 33.1
            1320000                   12                3.488                70.3                 29.6
            1380000                   16                4.651                75.0                 25.0
            1440000                    7                2.034                77.0                 22.9
            1500000                    7                2.034                79.0                 20.9
            1560000                    5                1.453                80.5                 19.4
            1620000                    7                2.034                82.5                 17.4
            1680000                    7                2.034                84.5                 15.4
     1740000                   1              0.290             84.8             15.1
     1800000                   6              1.744             86.6             13.3
     1860000                   3              0.872             87.5             12.5
     1920000                   7              2.034             89.5             10.4
     1980000                   0              0.000             89.5             10.4
     2040000                   8              2.325             91.8              8.1
     2100000                  10              2.906             94.7              5.2
     2160000                   1              0.290             95.0              4.9
     2220000                   2              0.581             95.6              4.3
     2280000                   3              0.872             96.5              3.4
     2340000                   2              0.581             97.0              2.9
     2400000                   1              0.290             97.3              2.6
     2460000                   1              0.290             97.6              2.3
     2520000                   0              0.000             97.6              2.3
     2580000                   1              0.290             97.9              2.0
     2640000                   3              0.872             98.8              1.1
     2700000                   2              0.581             99.4              0.5
     2760000                   2              0.581            100.0              0.0

REMAINING FREQUENCIES ARE ALL ZERO

                                        *  DISTL     3  *

ABSENSE REASON UPDATE RESPONSE TIME  EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

   ENTRIES IN TABLE        MEAN ARGUMENT         STANDARD DEVIATION

        1104                874841.649                598528.062

         UPPER                OBSERVED            PERCENT        CUMULATIVE        CUMULATIVE
         LIMIT                FREQUENCY          OF TOTAL        PERCENTAGE         REMAINDER

             0                   0              0.000              0.0             100.0
         60000                   3              0.271              0.2              99.7
        120000                  45              4.076              4.3              95.6
        180000                  46              4.166              8.5              91.4
        240000                  49              4.438             12.9              87.0
        300000                  40              3.623             16.5              83.4
        360000                  54              4.891             21.4              78.5
        420000                  62              5.615             27.0              72.9
        480000                  47              4.257             31.3              68.6
        540000                  46              4.166             35.5              64.4
        600000                  43              3.894             39.4              60.5
        660000                  46              4.166             43.5              56.4
        720000                  62              5.615             49.1              50.8
        780000                  38              3.442             52.6              47.3
        840000                  35              3.170             55.7              44.2
        900000                  40              3.623             59.4              40.5
        960000                  37              3.351             62.7              37.2
       1020000                  30              2.717             65.4              34.5
       1080000                  34              3.079             68.5              31.4
       1140000                  26              2.355             70.9              29.0
       1200000                  26              2.355             73.2              26.7
       1260000                  39              3.532             76.8              23.1
       1320000                  22              1.992             78.8              21.1
       1380000                  26              2.355             81.1              18.8
       1440000                  19              1.721             82.8              17.1
       1500000                  23              2.083             84.9              15.0
       1560000                  17              1.539             86.5              13.4
       1620000                  11              0.996             87.5              12.5
       1680000                  10              0.905             88.4              11.5
       1740000                   3              0.271             88.6              11.3
       1800000                   7              0.634             89.3              10.6
       1860000                   6              0.543             89.8              10.1
       1920000                  17              1.539             91.3               8.6
       1980000                  16              1.449             92.8               7.1
       2040000                  15              1.358             94.2               5.7
       2100000                  16              1.449             95.6               4.3
       2160000                   9              0.815             96.4               3.5
       2220000                   6              0.543             97.0               2.9
       2280000                   3              0.271             97.2               2.7
       2340000                   7              0.634             97.9               2.0
       2400000                   2              0.181             98.0               1.9
       2460000                   5              0.452             98.5               1.4
       2520000                   5              0.452             99.0               0.9
       2580000                 5                0.452              99.4                0.5
       2640000                 3                0.271              99.7                0.2
       2700000                 2                0.181              99.9                0.0
       2760000                 1                0.090             100.0                0.0

   REMAINING FREQUENCIES ARE ALL ZERO

                                         *  DISTL     4  *

TARDY-EARLY DISMISSAL RESPONSE TIME  EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

    ENTRIES IN TABLE         MEAN ARGUMENT         STANDARD DEVIATION

           133               972506.135                  640000.041

          UPPER             OBSERVED            PERCENT          CUMULATIVE          CUMULATIVE
          LIMIT             FREQUENCY          OF TOTAL          PERCENTAGE           REMAINDER

              0                 0                0.000               0.0               100.0
          60000                 0                0.000               0.0               100.0
         120000                 4                3.007               3.0                96.9
         180000                 5                3.759               6.7                93.2
         240000                 6                4.511              11.2                88.7
         300000                 7                5.263              16.5                83.4
         360000                 5                3.759              20.3                79.6
         420000                 9                6.766              27.0                72.9
         480000                 4                3.007              30.0                69.9
         540000                 3                2.255              32.3                67.6
         600000                 1                0.751              33.0                66.9
         660000                 7                5.263              38.3                61.6
         720000                 3                2.255              40.6                59.3
         780000                 4                3.007              43.6                56.3
         840000                 2                1.503              45.1                54.8
         900000                 6                4.511              49.6                50.3
         960000                 3                2.255              51.8                48.1
        1020000                 6                4.511              56.3                43.6
        1080000                 2                1.503              57.8                42.1
        1140000                 8                6.015              63.9                36.0
        1200000                 8                6.015              69.9                30.0
        1260000                 3                2.255              72.1                27.8
        1320000                 2                1.503              73.6                26.3
        1380000                 4                3.007              76.6                23.3
        1440000                 1                0.751              77.4                22.5
        1500000                 1                0.751              78.1                21.8
        1560000                 2                1.503              79.6                20.3
        1620000                 5                3.759              83.4                16.5
        1680000                 2                1.503              84.9                15.0
        1740000                 0                0.000              84.9                15.0
        1800000                 3                2.255              87.2                12.7
        1860000                 1                0.751              87.9                12.0
        1920000                 4                3.007              90.9                 9.0
        1980000                 0                0.000              90.9                 9.0
        2040000                 4                3.007              93.9                 6.0
        2100000                 3                2.255              96.2                 3.7
        2160000                 0                0.000              96.2                 3.7
        2220000                 1                0.751              96.9                 3.0
        2280000                 0                0.000              96.9                 3.0
        2340000                 0                0.000              96.9                 3.0
        2400000                 0                0.000              96.9                 3.0
        2460000                 0                0.000              96.9                 3.0
        2520000                 0                0.000              96.9                 3.0
        2580000                 0                0.000               6.4                93.5
        2640000                 0                0.000               6.4                93.5
        2700000                 0                0.000               6.4                93.5
        2760000                 0                0.000               6.4                93.5
        2820000                 0                0.000               6.4                93.5
        2880000                 0                0.000               6.4                93.5
        2940000                 0                0.000               6.4                93.5
        3000000                 0                0.000               6.4                93.5
        3060000                 0                0.000               6.4                93.5
        3120000                 0                0.000               6.4                93.5
        3180000                 0                0.000               6.4                93.5
        3240000                 0                0.000               6.4                93.5
        3300000                 0                0.000               6.4                93.5
        3360000                 0                0.000               6.4                93.5
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         3420000                 0               0.000              6.4              93.5
         3480000                 0               0.000              6.4              93.5
         3540000                 0               0.000              6.4              93.5
         3600000                 0               0.000              6.4              93.5
         3660000                 0               0.000              6.4              93.5
         3720000                 0               0.000              6.4              93.5
         3780000                 0               0.000              6.4              93.5
         3840000                 0               0.000              6.4              93.5
         3900000                 0               0.000              6.4              93.5
         3960000                 0               0.000              6.4              93.5
         4020000                 1               0.806              7.2              92.7
         4080000                 0               0.000              7.2              92.7
         4140000                 0               0.000              7.2              92.7
         4200000                 0               0.000              7.2              92.7
         4260000                 0               0.000              7.2              92.7
         4320000                 0               0.000              7.2              92.7
         4380000                 0               0.000              7.2              92.7
         4440000                 0               0.000              7.2              92.7
         4500000                 0               0.000              7.2              92.7
         4560000                 1               0.806              8.0              91.9
         4620000                 0               0.000              8.0              91.9
         4680000                 0               0.000              8.0              91.9
         4740000                 0               0.000              8.0              91.9
         4800000                 0               0.000              8.0              91.9
         4860000                 0               0.000              8.0              91.9
         4920000                 0               0.000              8.0              91.9
         4980000                 0               0.000              8.0              91.9
         5040000                 1               0.806              8.8              91.1
         5100000                 0               0.000              8.8              91.1
         5160000                 1               0.806              9.6              90.3
         5220000                 0               0.000              9.6              90.3
         5280000                 0               0.000              9.6              90.3
         5340000                 0               0.000              9.6              90.3
         5400000                 0               0.000              9.6              90.3
         5460000                 0               0.000              9.6              90.3
         5520000                 0               0.000              9.6              90.3
         5580000                 0               0.000              9.6              90.3
         5640000                 0               0.000              9.6              90.3
         5700000                 0               0.000              9.6              90.3
         5760000                 1               0.806             10.4              89.5
         5820000                 0               0.000             10.4              89.5
         5880000                 0               0.000             10.4              89.5
         5940000                 0               0.000             10.4              89.5


         6000000                 0               0.000             10.4              89.5
        OVERFLOW               111              89.516            100.0               0.0

   AVERAGE VALUE OF OVERFLOW    18537927.783

                                      *  DISTL    8  *

GUIDANCE COUNSELOR REQUEST RESPONSE TIME  EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

   ENTRIES IN TABLE          MEAN ARGUMENT          STANDARD DEVIATION

         124               16857977.274                  6778880.843

           UPPER               OBSERVED            PERCENT        CUMULATIVE          CUMULATIVE
           LIMIT               FREQUENCY          OF TOTAL        PERCENTAGE           REMAINDER

               0                 0               0.000              0.0             100.0
           60000                 0               0.000              0.0             100.0
          120000                 0               0.000              0.0             100.0
          180000                 0               0.000              0.0             100.0
          240000                 0               0.000              0.0             100.0
          300000                 1               0.806              0.8              99.1
          360000                 0               0.000              0.8              99.1
          420000                 0               0.000              0.8              99.1
          480000                 1               0.806              1.6              98.3
          540000                 0               0.000              1.6              98.3
          600000                 1               0.806              2.4              97.5
          660000                 0               0.000              2.4              97.5
          720000                 0               0.000              2.4              97.5
        780000               0                0.000             2.4               97.5
        840000               0                0.000             2.4               97.5
        900000               0                0.000             2.4               97.5
        960000               2                1.612             4.0               95.9
       1020000               0                0.000             4.0               95.9
       1080000               0                0.000             4.0               95.9
       1140000               0                0.000             4.0               95.9
       1200000               0                0.000             4.0               95.9
       1260000               0                0.000             4.0               95.9
       1320000               0                0.000             4.0               95.9
       1380000               0                0.000             4.0               95.9
       1440000               0                0.000             4.0               95.9
       1500000               0                0.000             4.0               95.9
       1560000               1                0.806             4.8               95.1
       1620000               0                0.000             4.8               95.1
       1680000               1                0.806             5.6               94.3
       1740000               0                0.000             5.6               94.3
       1800000               0                0.000             5.6               94.3
       1860000               0                0.000             5.6               94.3
       1920000               1                0.806             6.4               93.5
       1980000               0                0.000             6.4               93.5
       2040000               0                0.000             6.4               93.5
       2100000               0                0.000             6.4               93.5
       2160000               0                0.000             6.4               93.5
       2220000               0                0.000             6.4               93.5
       2280000               0                0.000             6.4               93.5
       2340000               0                0.000             6.4               93.5
       2400000               0                0.000             6.4               93.5
       2460000               0                0.000             6.4               93.5
       2520000               0                0.000             6.4               93.5

       2580000               0                0.000            96.9                3.0
       2640000               1                0.751            97.7                2.2
       2700000               3                2.255           100.0                0.0

   REMAINING FREQUENCIES ARE ALL ZERO

                                  *  DISTL    11  *

APL, RESPONSE TIME  EOB TO FIRST CHARACTER OF ANSWER (INTERVALS = .1 SECOND)

   ENTRIES IN TABLE         MEAN ARGUMENT          STANDARD DEVIATION

          10064                9924.312                   49344.001

          UPPER              OBSERVED          PERCENT         CUMULATIVE        CUMULATIVE
          LIMIT              FREQUENCY         OF TOTAL        PERCENTAGE         REMAINDER

              0                   0              0.000              0.0             100.0
           1000                 831              8.257              8.2              91.7
           2000                4978             49.463             57.7              42.2
           3000                1973             19.604             77.3              22.6
           4000                 526              5.226             82.5              17.4
           5000                 205              2.036             84.5              15.4
           6000                 159              1.579             86.1              13.8
           7000                 111              1.102             87.2              12.7
           8000                  73              0.725             87.9              12.0
           9000                  69              0.685             88.6              11.3
          10000                  72              0.715             89.3              10.6
          11000                  64              0.635             90.0               9.9
          12000                  64              0.635             90.6               9.3
          13000                  55              0.546             91.2               8.7
          14000                  39              0.387             91.6               8.3
          15000                  29              0.288             91.8               8.1
          16000                  33              0.327             92.2               7.7
          17000                  26              0.258             92.4               7.5
          18000                  25              0.248             92.7               7.2
          19000                  24              0.238             92.9               7.0
          20000                  21              0.208             93.1               6.8
          21000                  27              0.268             93.4               6.5
          22000                  17              0.168             93.6               6.3
          23000                  17              0.168             93.7               6.2
          24000                  18              0.178             93.9               6.0
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25000	22	0.218	94.1	5.8
26000	9	0.089	94.2	5.7
27000	12	0.119	94.3	5.6
28000	16	0.158	94.5	5.4
29000	18	0.178	94.7	5.2
30000	11	0.109	94.8	5.1
31000	13	0.129	94.9	5.0
32000	16	0.158	95.1	4.8
33000	14	0.139	95.2	4.7
34000	9	0.089	95.3	4.6
35000	7	0.069	95.4	4.5
36000	12	0.119	95.5	4.4
37000	8	0.079	95.6	4.3
38000	9	0.089	95.7	4.2
39000	5	0.049	95.7	4.2
40000	2	0.019	95.7	4.2
41000	5	0.049	95.8	4.1
42000	15	0.149	95.9	4.0
43000	6	0.059	96.0	3.9
44000	6	0.059	96.0	3.9
45000	8	0.079	96.1	3.8
46000	5	0.049	96.2	3.7
47000	7	0.069	96.2	3.7
48000	7	0.069	96.3	3.6
49000	11	0.109	96.4	3.5
50000	14	0.139	96.6	3.3
51000	8	0.079	96.6	3.3
52000	2	0.019	96.7	3.2
53000	1	0.009	96.7	3.2
54000	4	0.039	96.7	3.2
55000	5	0.049	96.8	3.1
56000	4	0.039	96.8	3.1
57000	4	0.039	96.8	3.1
58000	2	0.019	96.9	3.0
59000	8	0.079	96.9	3.0
60000	3	0.029	97.0	2.9
61000	4	0.039	97.0	2.9
62000	3	0.029	97.0	2.9
63000	4	0.039	97.1	2.8
64000	1	0.009	97.1	2.8
65000	4	0.039	97.1	2.8
66000	3	0.029	97.2	2.7
67000	4	0.039	97.2	2.7
68000	6	0.059	97.3	2.6
69000	1	0.009	97.3	2.6
70000	4	0.039	97.3	2.6
71000	2	0.019	97.3	2.6
72000	2	0.019	97.3	2.6
73000	4	0.039	97.4	2.5
74000	2	0.019	97.4	2.5
75000	2	0.019	97.4	2.5
76000	3	0.029	97.5	2.4
77000	3	0.029	97.5	2.4
78000	3	0.029	97.5	2.4
79000	4	0.039	97.6	2.3
80000	1	0.009	97.6	2.3
81000	5	0.049	97.6	2.3
82000	4	0.039	97.7	2.2
83000	4	0.039	97.7	2.2
84000	1	0.009	97.7	2.2
85000	6	0.059	97.8	2.1
86000	0	0.000	97.8	2.1
87000	2	0.019	97.8	2.1
88000	4	0.039	97.8	2.1
89000	4	0.039	97.9	2.0
90000	1	0.009	97.9	2.0
91000	1	0.009	97.9	2.0
92000	3	0.029	97.9	2.0
93000	1	0.009	97.9	2.0
94000	1	0.009	97.9	2.0
95000	4	0.039	98.0	1.9
96000	0	0.000	98.0	1.9
97000	1	0.009	98.0	1.9
98000	4	0.039	98.0	1.9
99000	1	0.009	98.0	1.9

100000	3	0.029	98.1	1.8
101000	1	0.009	98.1	1.8
102000	2	0.019	98.1	1.8
103000	4	0.039	98.1	1.8
104000	5	0.049	98.2	1.7
105000	2	0.019	98.2	1.7
106000	2	0.019	98.2	1.7
107000	1	0.009	98.2	1.7
108000	2	0.019	98.3	1.6
109000	1	0.009	98.3	1.6
110000	1	0.009	98.3	1.6
111000	3	0.029	98.3	1.6
112000	2	0.019	98.3	1.6
113000	2	0.019	98.3	1.6
114000	1	0.009	98.4	1.5
115000	3	0.029	98.4	1.5
116000	2	0.019	98.4	1.5
117000	3	0.029	98.4	1.5
118000	1	0.009	98.4	1.5
119000	2	0.019	98.5	1.4
120000	0	0.000	98.5	1.4
121000	2	0.019	98.5	1.4
122000	2	0.019	98.5	1.4
123000	0	0.000	98.5	1.4
124000	0	0.000	98.5	1.4
125000	2	0.019	98.5	1.4
126000	0	0.000	98.5	1.4
127000	2	0.019	98.5	1.4
128000	0	0.000	98.5	1.4
129000	4	0.039	98.6	1.3
130000	1	0.009	98.6	1.3
131000	0	0.000	98.6	1.3
132000	0	0.000	98.6	1.3
133000	1	0.009	98.6	1.3
134000	1	0.009	98.6	1.3
135000	3	0.029	98.6	1.3
136000	1	0.009	98.6	1.3
137000	1	0.009	98.7	1.2
138000	2	0.019	98.7	1.2
139000	2	0.019	98.7	1.2
140000	1	0.009	98.7	1.2
141000	1	0.009	98.7	1.2
142000	0	0.000	98.7	1.2
143000	0	0.000	98.7	1.2
144000	0	0.000	98.7	1.2
145000	0	0.000	98.7	1.2
146000	0	0.000	98.7	1.2
147000	0	0.000	98.7	1.2
148000	2	0.019	98.7	1.2
149000	0	0.000	98.7	1.2
150000	0	0.000	98.7	1.2
151000	0	0.000	98.7	1.2
152000	1	0.009	98.7	1.2
153000	4	0.039	98.8	1.1
154000	0	0.000	98.8	1.1
155000	1	0.009	98.8	1.1
156000	2	0.019	98.8	1.1
157000	0	0.000	98.8	1.1
158000	0	0.000	98.8	1.1
159000	0	0.000	98.8	1.1
160000	0	0.000	98.8	1.1
161000	0	0.000	98.8	1.1
162000	0	0.000	98.8	1.1
163000	2	0.019	98.8	1.1
164000	0	0.000	98.8	1.1
165000	1	0.009	98.8	1.1
166000	0	0.000	98.8	1.1
167000	0	0.000	98.8	1.1
168000	2	0.019	98.9	1.0
169000	0	0.000	98.9	1.0
170000	2	0.019	98.9	1.0
171000	2	0.019	98.9	1.0
172000	2	0.019	98.9	1.0
173000	1	0.009	98.9	1.0
174000	0	0.000	98.9	1.0
175000	2	0.019	99.0	0.9
176000	1	0.009	99.0	0.9

177000	1	0.009	99.0	0.9
178000	0	0.000	99.0	0.9
179000	1	0.009	99.0	0.9
180000	1	0.009	99.0	0.9
181000	0	0.000	99.0	0.9
182000	0	0.000	99.0	0.9
183000	0	0.000	99.0	0.9
184000	0	0.000	99.0	0.9
185000	0	0.000	99.0	0.9
186000	0	0.000	99.0	0.9
187000	1	0.009	99.0	0.9
188000	1	0.009	99.0	0.9
189000	0	0.000	99.0	0.9
190000	1	0.009	99.0	0.9
191000	1	0.009	99.0	0.9
192000	2	0.019	99.1	0.8
193000	1	0.009	99.1	0.8
194000	1	0.009	99.1	0.8
195000	0	0.000	99.1	0.8
196000	1	0.009	99.1	0.8
197000	0	0.000	99.1	0.8
198000	0	0.000	99.1	0.8
199000	0	0.000	99.1	0.8
200000	1	0.009	99.1	0.8
201000	0	0.000	99.1	0.8
202000	0	0.000	99.1	0.8
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204000	0	0.000	99.1	0.8
205000	2	0.019	99.1	0.8
206000	0	0.000	99.1	0.8
207000	0	0.000	99.1	0.8
208000	3	0.029	99.1	0.8
209000	1	0.009	99.2	0.7
210000	0	0.000	99.2	0.7
211000	0	0.000	99.2	0.7
212000	1	0.009	99.2	0.7
213000	1	0.009	99.2	0.7
214000	1	0.009	99.2	0.7
215000	1	0.009	99.2	0.7
216000	0	0.000	99.2	0.7
217000	1	0.009	99.2	0.7
218000	0	0.000	99.2	0.7
219000	1	0.009	99.2	0.7
220000	2	0.019	99.2	0.7
221000	0	0.000	99.2	0.7
222000	0	0.000	99.2	0.7
223000	0	0.000	99.2	0.7
224000	0	0.000	99.2	0.7
225000	2	0.019	99.3	0.6
226000	0	0.000	99.3	0.6
227000	0	0.000	99.3	0.6
228000	0	0.000	99.3	0.6
229000	0	0.000	99.3	0.6
230000	0	0.000	99.3	0.6
231000	1	0.009	99.3	0.6
232000	0	0.000	99.3	0.6
233000	0	0.000	99.3	0.6
234000	0	0.000	99.3	0.6
235000	0	0.000	99.3	0.6
236000	1	0.009	99.3	0.6
237000	0	0.000	99.3	0.6
238000	0	0.000	99.3	0.6
239000	1	0.009	99.3	0.6
240000	1	0.009	99.3	0.6
241000	0	0.000	99.3	0.6
242000	1	0.009	99.3	0.6
243000	0	0.000	99.3	0.6
244000	0	0.000	99.3	0.6
245000	0	0.000	99.3	0.6
246000	0	0.000	99.3	0.6
247000	0	0.000	99.3	0.6
248000	0	0.000	99.3	0.6
249000	0	0.000	99.3	0.6
250000	0	0.000	99.3	0.6
251000	0	0.000	99.3	0.6
252000	1	0.009	99.3	0.6

253000	0	0.000	99.3	0.6
254000	0	0.000	99.3	0.6
255000	0	0.000	99.3	0.6
256000	0	0.000	99.3	0.6
257000	0	0.000	99.3	0.6
258000	0	0.000	99.3	0.6
259000	0	0.000	99.3	0.6
260000	0	0.000	99.3	0.6
261000	0	0.000	99.3	0.6
262000	0	0.000	99.3	0.6
263000	0	0.000	99.3	0.6
264000	0	0.000	99.3	0.6
265000	0	0.000	99.3	0.6
266000	0	0.000	99.3	0.6
267000	0	0.000	99.3	0.6
268000	0	0.000	99.3	0.6
269000	0	0.000	99.3	0.6
270000	1	0.009	99.3	0.6
271000	0	0.000	99.3	0.6
272000	0	0.000	99.3	0.6
273000	0	0.000	99.3	0.6
274000	0	0.000	99.3	0.6
275000	0	0.000	99.3	0.6
276000	0	0.000	99.3	0.6
277000	0	0.000	99.3	0.6
278000	1	0.009	99.3	0.6
279000	0	0.000	99.3	0.6
280000	0	0.000	99.3	0.6
281000	0	0.000	99.3	0.6
282000	0	0.000	99.3	0.6
283000	0	0.000	99.3	0.6
284000	0	0.000	99.3	0.6
285000	0	0.000	99.3	0.6
286000	0	0.000	99.3	0.6
287000	0	0.000	99.3	0.6
288000	0	0.000	99.3	0.6
289000	0	0.000	99.3	0.6
290000	0	0.000	99.3	0.6
291000	0	0.000	99.3	0.6
292000	0	0.000	99.3	0.6
293000	0	0.000	99.3	0.6
294000	1	0.009	99.3	0.6
295000	0	0.000	99.3	0.6
296000	0	0.000	99.3	0.6
297000	0	0.000	99.3	0.6
298000	1	0.009	99.4	0.5
299000	0	0.000	99.4	0.5
300000	0	0.000	99.4	0.5
301000	0	0.000	99.4	0.5
302000	0	0.000	99.4	0.5
303000	0	0.000	99.4	0.5
304000	0	0.000	99.4	0.5
305000	1	0.009	99.4	0.5
306000	0	0.000	99.4	0.5
307000	1	0.009	99.4	0.5
308000	0	0.000	99.4	0.5
309000	0	0.000	99.4	0.5
310000	0	0.000	99.4	0.5
311000	0	0.000	99.4	0.5
312000	0	0.000	99.4	0.5
313000	0	0.000	99.4	0.5
314000	0	0.000	99.4	0.5
315000	1	0.009	99.4	0.5
316000	0	0.000	99.4	0.5
317000	0	0.000	99.4	0.5
318000	0	0.000	99.4	0.5
319000	0	0.000	99.4	0.5
320000	0	0.000	99.4	0.5
321000	0	0.000	99.4	0.5
322000	0	0.000	99.4	0.5
323000	0	0.000	99.4	0.5
324000	0	0.000	99.4	0.5
325000	0	0.000	99.4	0.5
326000	0	0.000	99.4	0.5
327000	1	0.009	99.4	0.5

328000	0	0.000	99.4	0.5
329000	0	0.000	99.4	0.5
330000	0	0.000	99.4	0.5
331000	1	0.009	99.4	0.5
332000	0	0.000	99.4	0.5
333000	0	0.000	99.4	0.5
334000	0	0.000	99.4	0.5
335000	0	0.000	99.4	0.5
336000	0	0.000	99.4	0.5
337000	0	0.000	99.4	0.5
338000	0	0.000	99.4	0.5
339000	0	0.000	99.4	0.5
340000	0	0.000	99.4	0.5
341000	0	0.000	99.4	0.5
342000	0	0.000	99.4	0.5
343000	0	0.000	99.4	0.5
344000	0	0.000	99.4	0.5
345000	1	0.009	99.4	0.5
346000	0	0.000	99.4	0.5
347000	1	0.009	99.4	0.5
348000	0	0.000	99.4	0.5
349000	0	0.000	99.4	0.5
350000	0	0.000	99.4	0.5
351000	0	0.000	99.4	0.5
352000	1	0.009	99.4	0.5
353000	0	0.000	99.4	0.5
354000	0	0.000	99.4	0.5
355000	0	0.000	99.4	0.5
356000	0	0.000	99.4	0.5
357000	0	0.000	99.4	0.5
358000	0	0.000	99.4	0.5
359000	0	0.000	99.4	0.5
360000	0	0.000	99.4	0.5
361000	0	0.000	99.4	0.5
362000	0	0.000	99.4	0.5
363000	0	0.000	99.4	0.5
364000	0	0.000	99.4	0.5
365000	0	0.000	99.4	0.5
366000	0	0.000	99.4	0.5
367000	0	0.000	99.4	0.5
368000	0	0.000	99.4	0.5
369000	1	0.009	99.4	0.5
370000	2	0.019	99.5	0.4
371000	0	0.000	99.5	0.4
372000	0	0.000	99.5	0.4
373000	0	0.000	99.5	0.4
374000	0	0.000	99.5	0.4
375000	0	0.000	99.5	0.4
376000	0	0.000	99.5	0.4
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382000	0	0.000	99.5	0.4
383000	0	0.000	99.5	0.4
384000	0	0.000	99.5	0.4
385000	0	0.000	99.5	0.4
386000	0	0.000	99.5	0.4
387000	0	0.000	99.5	0.4
388000	0	0.000	99.5	0.4
389000	0	0.000	99.5	0.4
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394000	0	0.000	99.5	0.4
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396000	0	0.000	99.5	0.4
397000	0	0.000	99.5	0.4
398000	1	0.009	99.5	0.4
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400000	0	0.000	99.5	0.4
401000	1	0.009	99.5	0.4
402000	0	0.000	99.5	0.4
403000	0	0.000	99.5	0.4

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405000     1     0.009     99.5     0.4
406000     0     0.000     99.5     0.4
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408000     0     0.000     99.5     0.4
409000     0     0.000     99.5     0.4
410000     0     0.000     99.5     0.4
411000     0     0.000     99.5     0.4
412000     1     0.009     99.5     0.4
413000     0     0.000     99.5     0.4
414000     0     0.000     99.5     0.4
415000     0     0.000     99.5     0.4
416000     0     0.000     99.5     0.4
417000     0     0.000     99.5     0.4
418000     0     0.000     99.5     0.4
419000     0     0.000     99.5     0.4
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421000     0     0.000     99.5     0.4
422000     1     0.009     99.5     0.4
423000     0     0.000     99.5     0.4
424000     0     0.000     99.5     0.4
425000     0     0.000     99.5     0.4
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427000     0     0.000     99.5     0.4
428000     0     0.000     99.5     0.4
429000     0     0.000     99.5     0.4
430000     0     0.000     99.5     0.4
431000     0     0.000     99.5     0.4
432000     0     0.000     99.5     0.4
433000     0     0.000     99.5     0.4
434000     1     0.009     99.5     0.4
435000     0     0.000     99.5     0.4
436000     0     0.000     99.5     0.4
437000     0     0.000     99.5     0.4
438000     0     0.000     99.5     0.4
439000     0     0.000     99.5     0.4
440000     0     0.000     99.5     0.4
441000     0     0.000     99.5     0.4
442000     0     0.000     99.5     0.4
443000     1     0.009     99.6     0.3
444000     0     0.000     99.6     0.3
445000     0     0.000     99.6     0.3
446000     0     0.000     99.6     0.3
447000     0     0.000     99.6     0.3
448000     0     0.000     99.6     0.3
449000     1     0.009     99.6     0.3
450000     0     0.000     99.6     0.3
451000     0     0.000     99.6     0.3
452000     0     0.000     99.6     0.3
453000     0     0.000     99.6     0.3
454000     0     0.000     99.6     0.3
455000     0     0.000     99.6     0.3
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457000     0     0.000     99.6     0.3
458000     0     0.000     99.6     0.3
459000     1     0.009     99.6     0.3
460000     1     0.009     99.6     0.3
461000     0     0.000     99.6     0.3
462000     0     0.000     99.6     0.3
463000     0     0.000     99.6     0.3
464000     0     0.000     99.6     0.3
465000     1     0.009     99.6     0.3
466000     0     0.000     99.6     0.3
467000     0     0.00[illegible]     99.6     0.3
468000     0     0.000     99.6     0.3
469000     0     0.000     99.6     0.3
470000     0     0.000     99.6     0.3
471000     0     0.000     99.6     0.3
472000     1     0.009     99.6     0.3
473000     0     0.000     99.6     0.3
474000     0     0.000     99.6     0.3
475000     0     0.000     99.6     0.3
476000     0     0.000     99.6     0.3
477000     1     0.009     99.6     0.3
478000     0     0.000     99.6     0.3
479000     0     0.000     99.6     0.3
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481000	0	0.000	99.6	0.3
482000	0	0.000	99.6	0.3
483000	0	0.000	99.6	0.3
484000	0	0.000	99.6	0.3
485000	0	0.000	99.6	0.3
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489000	0	0.000	99.6	0.3
490000	0	0.000	99.6	0.3
491000	0	0.000	99.6	0.3
492000	0	0.000	99.6	0.3
493000	0	0.000	99.6	0.3
494000	1	0.009	99.6	0.3
495000	0	0.000	99.6	0.3
496000	0	0.000	99.6	0.3
497000	0	0.000	99.6	0.3
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503000	0	0.000	99.6	0.3
504000	0	0.000	99.6	0.3
505000	0	0.000	99.6	0.3
506000	1	0.009	99.6	0.3
507000	1	0.009	99.6	0.3
508000	0	0.000	99.6	0.3
509000	0	0.000	99.6	0.3
510000	0	0.000	99.6	0.3
511000	0	0.000	99.6	0.3
512000	0	0.000	99.6	0.3
513000	1	0.009	99.7	0.2
514000	1	0.009	99.7	0.2
515000	0	0.000	99.7	0.2
516000	0	0.000	99.7	0.2
517000	0	0.000	99.7	0.2
518000	0	0.000	99.7	0.2
519000	0	0.000	99.7	0.2
520000	0	0.000	99.7	0.2
521000	0	0.000	99.7	0.2
522000	0	0.000	99.7	0.2
523000	0	0.000	99.7	0.2
524000	0	0.000	99.7	0.2
525000	0	0.000	99.7	0.2
526000	0	0.000	99.7	0.2
527000	0	0.000	99.7	0.2
528000	0	0.000	99.7	0.2
529000	0	0.000	99.7	0.2
530000	0	0.000	99.7	0.2
531000	0	0.000	99.7	0.2
532000	0	0.000	99.7	0.2
533000	0	0.000	99.7	0.2
534000	0	0.000	99.7	0.2
535000	0	0.000	99.7	0.2
536000	0	0.000	99.7	0.2
537000	2	0.019	99.7	0.2
538000	0	0.000	99.7	0.2
539000	0	0.000	99.7	0.2
540000	0	0.000	99.7	0.2
541000	0	0.000	99.7	0.2
542000	1	0.009	99.7	0.2
543000	0	0.000	99.7	0.2
544000	0	0.000	99.7	0.2
545000	0	0.000	99.7	0.2
546000	0	0.000	99.7	0.2
547000	0	0.000	99.7	0.2
548000	0	0.000	99.7	0.2
549000	0	0.000	99.7	0.2
550000	0	0.000	99.7	0.2
551000	0	0.000	99.7	0.2
552000	0	0.000	99.7	0.2
553000	0	0.000	99.7	0.2
554000	0	0.000	99.7	0.2
555000	0	0.000	99.7	0.2

```
          556000                 1               0.009              99.7               0.2
          557000                 0               0.000              99.7               0.2
          558000                 1               0.009              99.7               0.2
          559000                 0               0.000              99.7               0.2
          560000                 0               0.000              99.7               0.2
          561000                 1               0.009              99.7               0.2
          562000                 0               0.000              99.7               0.2
          563000                 0               0.000              99.7               0.2
          564000                 0               0.000              99.7               0.2
          565000                 0               0.000              99.7               0.2
          566000                 0               0.000              99.7               0.2
          567000                 0               0.000              99.7               0.2
          568000                 0               0.000              99.7               0.2
          569000                 0               0.000              99.7               0.2
          570000                 0               0.000              99.7               0.2
          571000                 0               0.000              99.7               0.2
          572000                 0               0.000              99.7               0.2
          573000                 0               0.000              99.7               0.2
          574000                 0               0.000              99.7               0.2
          575000                 0               0.000              99.7               0.2
          576000                 1               0.009              99.7               0.2
          577000                 0               0.000              99.7               0.2
          578000                 0               0.000              99.7               0.2
          579000                 0               0.000              99.7               0.2
          580000                 0               0.000              99.7               0.2
          581000                 0               0.000              99.7               0.2
          582000                 0               0.000              99.7               0.2
          583000                 0               0.000              99.7               0.2
          584000                 0               0.000              99.7               0.2
          585000                 0               0.000              99.7               0.2
          586000                 0               0.000              99.7               0.2
          587000                 0               0.000              99.7               0.2
          588000                 0               0.000              99.7               0.2
          589000                 0               0.000              99.7               0.2
          590000                 0               0.000              99.7               0.2
          591000                 0               0.000              99.7               0.2
          592000                 0               0.000              99.7               0.2
          593000                 0               0.000              99.7               0.2
          594000                 0               0.000              99.7               0.2
          595000                 0               0.000              99.7               0.2
          596000                 0               0.000              99.7               0.2
          597000                 0               0.000              99.7               0.2
          598000                 0               0.000              99.7               0.2
          599000                 0               0.000              99.7               0.2
          600000                 0               0.000              99.7               0.2
        OVERFLOW                22               0.218             100.0               0.0

   AVERAGE VALUE OF OVERFLOW       762339.454



                                             *  DISTL    12  *

APL, RESPONSE TIME  EOB TO LPSW (INTERVALS = .1 SECOND)

     ENTRIES IN TABLE           MEAN ARGUMENT          STANDARD DEVIATION

           10063                  1026.860                       524.000

              UPPER              OBSERVED            PERCENT          CUMULATIVE           CUMULATIVE
              LIMIT              FREQUENCY           OF TOTAL         PERCENTAGE            REMAINDER

                  0                      0              0.000                0.0                100.0
               1000                   5880             58.431               58.4                 41.5
               2000                   3660             36.370               94.8                  5.1
               3000                    443              4.402               99.2                  0.7
               4000                     64              0.635               99.8                  0.1
               5000                     12              0.119               99.9                  0.0
               6000                      4              0.039              100.0                  0.0

     REMAINING FREQUENCIES ARE ALL ZERO
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APL, CPU TIME REQUIRED (INTERVALS = .1 SECOND)
                                                        STANDARD DEVIATION
     ENTRIES IN TABLE          MEAN ARGUMENT
                                                              7360.000
                9456               2702.092
                                                                                                    CUMULATIVE
                                                                         CUMULATIVE                 REMAINDER
                 UPPER              OBSERVED             PERCENT         PERCENTAGE
                 LIMIT              FREQUENCY            OF TOTAL
                     0                     0               0.000             0.0                   100.0
                  1000                  7378              78.024            78.0                    21.9
                  2000                   465               4.917            82.9                    17.0
                  3000                   176               1.861            84.8                    15.1
                  4000                   145               1.533            86.3                    13.6
                  5000                   146               1.543            87.8                    12.1
                  6000                   119               1.258            89.1                    10.8
                  7000                   102               1.078            90.2                     9.7
                  8000                   127               1.343            91.5                     8.4
                  9000                   116               1.226            92.7                     7.2
                 10000                   113               1.195            93.9                     6.0
                 11000                    64               0.676            94.6                     5.3
                 12000                    57               0.602            95.2                     4.7
                 13000                    50               0.528            95.7                     4.2
                 14000                    28               0.296            96.0                     3.9
                 15000                    27               0.285            96.3                     3.6
                 16000                    23               0.243            96.6                     3.3
                 17000                    23               0.243            96.8                     3.1
                 18000                    10               0.105            96.9                     3.0
                 19000                    16               0.169            97.1                     2.8
                 20000                    14               0.148            97.2                     2.7
                 21000                     6               0.063            97.3                     2.6
                 22000                     3               0.031            97.3                     2.6
                 23000                     8               0.084            97.4                     2.5
                 24000                     5               0.052            97.5                     2.4
                 25000                     5               0.052            97.5                     2.4
                 26000                     7               0.074            97.6                     2.3
                 27000                     5               0.052            97.6                     2.3
                 28000                     6               0.063            97.7                     2.2
                 29000                     8               0.084            97.8                     2.1
                 30000                     5               0.052            97.8                     2.1
                 31000                     6               0.063            97.9                     2.0
                 32000                     5               0.052            98.0                     1.9
                 33000                     7               0.074            98.0                     1.9
                 34000                     6               0.063            98.1                     1.8
                 35000                     9               0.095            98.2                     1.7
                 36000                     5               0.052            98.2                     1.7
                 37000                     7               0.074            98.3                     1.6
                 38000                     8               0.084            98.4                     1.5
                 39000                     8               0.084            98.5                     1.4
                 40000                     3               0.031            98.5                     1.4
                 41000                     4               0.042            98.6                     1.3
                 42000                     9               0.095            98.7                     1.2
                 43000                     3               0.031            98.7                     1.2
                 44000                     7               0.074            98.8                     1.1
                 45000                    10               0.105            98.9                     1.0
                 46000                     5               0.052            98.9                     1.0
                 47000                     2               0.021            98.9                     1.0
                 48000                     7               0.074            99.0                     0.9
                 49000                     5               0.052            99.1                     0.8
                 50000                     6               0.063            99.1                     0.8
                 51000                     4               0.042            99.2                     0.7
                 52000                     8               0.084            99.3                     0.6
                 53000                     4               0.042            99.3                     0.6
                 54000                     9               0.095            99.4                     0.5
                 55000                     6               0.063            99.5                     0.4
                 56000                     6               0.063            99.5                     0.4
                 57000                     7               0.074            99.6                     0.3
                 58000                     5               0.052            99.7                     0.2
                 59000                     6               0.063            99.7                     0.2
                 60000                     7               0.074            99.8                     0.1
                 61000                     7               0.074            99.9                     0.0
                 62000                     4               0.042            99.9                     0.0
                 63000                     4               0.042           100.0                     0.0

         REMAINING FREQUENCIES ARE ALL ZERO
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                                        * DISTL    14 *

APL, PERCENT OF CPU UNAVAILABLE  100(1-CPU TIME REQUIRED/ELAPSED TIME) (INTERVALS = 1 PERCENT)

     ENTRIES IN TABLE          MEAN ARGUMENT          STANDARD DEVIATION

              9456                  25.701                     23.375

                UPPER              OBSERVED           PERCENT          CUMULATIVE          CUMULATIVE
                LIMIT              FREQUENCY          OF TOTAL         PERCENTAGE          REMAINDER

                   0                  623              6.588               6.5                93.4
                   1                  384              4.060              10.6                89.3
                   2                  394              4.166              14.8                85.1
                   3                  227              2.400              17.2                82.7
                   4                  201              2.125              19.3                80.6
                   5                  206              2.178              21.5                78.4
                   6                  162              1.713              23.2                76.7
                   7                  210              2.220              25.4                74.5
                   8                  221              2.337              27.7                72.2
                   9                  198              2.093              29.9                70.1
                  10                  235              2.485              32.3                67.6
                  11                  232              2.453              34.8                65.1
                  12                  206              2.178              37.0                62.9
                  13                  222              2.347              39.3                60.6
                  14                  196              2.072              41.4                58.5
                  15                  217              2.294              43.7                56.2
                  16                  202              2.136              45.8                54.1
                  17                  190              2.009              47.8                52.1
                  18                  214              2.263              50.1                49.8
                  19                  185              1.956              52.0                47.9
                  20                  174              1.840              53.9                46.0
                  21                  156              1.649              55.5                44.4
                  22                  152              1.607              57.1                42.8
                  23                  150              1.586              58.7                41.2
                  24                  145              1.533              60.3                39.6
                  25                  123              1.300              61.6                38.3
                  26                  135              1.427              63.0                36.9
                  27                  107              1.131              64.1                35.8
                  28                  107              1.131              65.2                34.7
                  29                  105              1.110              66.4                33.5
                  30                  112              1.184              67.5                32.4
                  31                   84              0.888              68.4                31.5
                  32                   83              0.877              69.3                30.6
                  33                   89              0.941              70.2                29.7
                  34                   89              0.941              71.2                28.7
                  35                   76              0.803              72.0                27.9
                  36                   89              0.941              72.9                27.0
                  37                   74              0.782              73.7                26.2
                  38                   64              0.676              74.4                25.5
                  39                   86              0.909              75.3                24.6
                  40                   75              0.793              76.1                23.8
                  41                   70              0.740              76.8                23.1
                  42                   67              0.708              77.5                22.4
                  43                   54              0.571              78.1                21.8
                  44                   74              0.782              78.9                21.0
                  45                   56              0.592              79.5                20.4
                  46                   63              0.666              80.2                19.7
                  47                   63              0.666              80.8                19.1
                  48                   65              0.687              81.5                18.4
                  49                   52              0.549              82.1                17.8
                  50                   65              0.687              82.7                17.2
                  51                   64              0.676              83.4                16.5
                  52                   51              0.539              84.0                15.9
                  53                   48              0.507              84.5                15.4
                  54                   69              0.729              85.2                14.7
                  55                   67              0.708              85.9                14.0
                  56                   57              0.602              86.5                13.4
                  57                   53              0.560              87.1                12.8
                  58                   52              0.549              87.6                12.3
                  59                   57              0.602              88.2                11.7
                  60                   51              0.539              88.8                11.1
                  61                   57              0.602              89.4                10.5
                  62                   42              0.444              89.8                10.1
                  63                   50              0.528              90.3                 9.6
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   64                 46          0.486           90.8                9.1
   65                 49          0.518           91.3                8.6
   66                 38          0.401           91.7                8.2
   67                 39          0.412           92.2                7.7
   68                 39          0.412           92.6                7.3
   69                 31          0.327           92.9                7.0
   70                 39          0.412           93.3                6.6
   71                 38          0.401           93.7                6.2
   72                 35          0.370           94.1                5.8
   73                 34          0.359           94.4                5.5
   74                 35          0.370           94.8                5.1
   75                 33          0.348           95.2                4.7
   76                 27          0.285           95.4                4.5
   77                 31          0.327           95.8                4.1
   78                 36          0.380           96.2                3.7
   79                 26          0.274           96.4                3.5
   80                 27          0.285           96.7                3.2
   81                 30          0.317           97.0                2.9
   82                 31          0.327           97.4                2.5
   83                 36          0.380           97.7                2.2
   84                 26          0.274           98.0                1.9
   85                 23          0.243           98.3                1.6
   86                 27          0.285           98.5                1.4
   87                 15          0.158           98.7                1.2
   88                 18          0.190           98.9                1.0
   89                 27          0.285           99.2                0.7
   90                 17          0.179           99.4                0.5
   91                 16          0.169           99.5                0.4
   92                 12          0.126           99.7                0.2
   93                 10          0.105           99.8                0.1
   94                  9          0.095           99.9                0.0
   95                  6          0.063           99.9                0.0
   96                  2          0.021           99.9                0.0
   97                  1          0.010          100.0                0.0

REMAINING FREQUENCIES ARE ALL ZERO
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